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DEPARTMENT OF TRANSPORTATION
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TECHNICAL REPORT NO. 80-1

D96103; PIN 1700.18.325
TROY-GREEN ISLAND BRIDGE SUBSTRUCTURE
FINAL REPORT ON THE CONDITION OF THE
EAST PIER TREMIE CONCRETE

MAY 1980

materials
bureau
technical
services
subdivision

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TROY-GREEN ISLAND BRIDGE SUBSTRUCTURE, CONTRACT II
FINAL REPORT ON THE CONDITION
OF THE
EAST PIER TREMIE CONCRETE

MAY 1980

by

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MATERIALS BUREAU

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I. INTRODUCTION

This report documents the work conducted by the Technical Services Subdivision to determine the condition of the tremie concrete placed in the east pier substructure of the Troy-Green Island Bridge (DOT Contract D96103) in August, 1979. This augments the Subdivision's preliminary report, transmitted by memorandum to the Structures Subdivision on October 3, 1979 (see Appendix A).

The primary purpose of this report is to present in final form the complete data used to evaluate the tremie's condition. This data lead to the conclusion that the tremie placement was unsatisfactory and the recommendation that corrective work to the tremie was necessary. A secondary purpose of this report is to describe the most probable causes for the deficiencies found in the tremie.

II. BACKGROUND

This section summarizes the events leading to the preparation of this report. Detailed accounts of these events can be obtained from project records and correspondence.

Contract plans for the east pier substructure require placement of a 13 ft. thick concrete tremie seal directly upon exposed sound shale bedrock on the river bottom. The tremie extends the full length and width of the east pier cofferdam (122.5 ft. by 33.5 ft.), requiring approximately 2000 cubic yards of concrete. Specifications call for the Department's standard Class G concrete (Item 555.06), a mix designed specifically for underwater tremie placements.

Besides providing the seal necessary to dewater the cofferdam for subsequent work, this block is designed to be a load bearing member carrying all east pier loads directly to bedrock.

The Contractor placed the east pier tremie in a continuous pour over a 36-hour period on August 27 and 28, 1979. A single conveyor belt system delivered concrete from the truck discharge point on the Troy shore to a single tremie tube and hopper in the cofferdam. The rate of concrete placement averaged approximately 50 cubic yards per hour. The placement progressed generally from the north to the south end of the cofferdam.

Concrete delivery to the job was slowed on two occasions when the supplier's plant was shut down to chip away excessive deposits of hardened cement mortar that accumulated in the mixer drum. These deposits resulted from mixing numerous batches of the Class G mix, which has a higher cement content than other general purpose mixes. Concrete continued to be supplied to the job during these shutdowns from the

supplier's dry batch plant. Four truckloads of concrete supplied from the dry batch plant were rejected for containing an excessive number of balls of dry, unmixed cement.

In using only one tremie hopper and tube, the Contractor relied heavily on the flow capabilities of the mix to achieve a satisfactory placement despite advice by the Engineer to install additional tremie tubes. During the placement, it became apparent to the Contractor that the mix flow characteristics were less than those required for the method of placement the Contractor chose. Evidence of this included observations of steep concrete discharge slopes (1:3 and steeper) at the point of deposition and observations by divers of mix segregation, with a wave of fine material preceding the deposited concrete.

The Contractor increased the number of deposition points, continuing to use only one tremie tube and hopper, in an attempt to compensate for the mix flow characteristics. This action resulted in moving the tremie hopper and tube (and breaking and re-establishing the seal with previously placed concrete contrary to the Specification requirements) approximately three dozen times. Each move of the tremie hopper and tube and the subsequent restart operations required considerable effort by the Contractor and resulted in significant interruptions in concrete placement. Much of that effort and much of the resulting interruption was caused by the difficulty the Contractor experienced maneuvering the equipment he employed for the pour.

Only 1717.5 cubic yards of concrete were placed when the computed top elevations for the tremie block were reached. This amounted to almost 300 cubic yards of concrete less than the computed required placement. Nothing was found at the project site or at the supplier's plant to account for a difference of such magnitude.

On September 4, 1979, after the required seven day curing period, the cofferdam was dewatered without incident. On September 6 the cofferdam was evacuated when the cofferdam steel sheeting was observed to have lifted up to 1.25' at the south end. The apparent lifting of the cofferdam occurred during a period when the river level had risen higher than normal due to heavy rains. The cofferdam was flooded by the Contractor and attempts were made to reseat the tremie block by applying surcharge loads. These efforts were not completely successful; it was estimated that the south end of the tremie block was still 4 inches off the bottom.

An investigation of the condition of the east pier tremie was subsequently initiated by the Technical Services Subdivision at the request of the Construction and Structures Subdivisions.

III. MATERIALS OBSERVED

This investigation has utilized data obtained from a number of sources. The data sources described here are in the possession of the Technical Services Subdivision.

A. Project Concrete Cylinders.

The concrete supplied to the project was sampled and tested in accordance with general specification requirements. Plastic concrete was sampled and tested at the point of truck discharge. Ten concrete cylinder pairs were cast during the pour for the required 28-day compressive strength testing.

These samples provide information concerning the properties expected from the concrete supplied to the project and placed in the east pier. This information is summarized in Appendices B and C.

B. Cores Drilled by Empire Soils Investigations, Inc.

Eleven cores were drilled by the Contractor in September, 1979. The eleven cores were taken at various locations in the tremie. The diagram in Appendix D indicates the core locations.

One core (TCE-3) extends the full depth of the tremie block and continues into rock. The other cores extend into the tremie to varying depths, most commonly eight feet. All eleven cores encounter a variety of segregated materials and portions of nine cores were unrecovered. Appendix G contains core photographs and Appendix E the core logs.

The materials observed by inspection of the cores fall into five categories.

1. Sound concrete.

This is concrete with the proper density, soundness and strength expected from concrete containing good quality materials, properly mixed and placed. A sound mortar paste is present with a good dispersion of fine and coarse aggregate through the paste. Little entrapped air is present, and virtually no honeycombing or other evidence of poorly consolidated concrete can be found. Sound concrete is found in approximately 60% of the total length of the eleven cores.

2. Concrete with deficient mortar paste.

This is concrete lacking the soundness and strength expected from properly mixed and placed concrete incorporating good quality materials. The mortar paste appears to be weakened and very susceptible to erosion, resulting in its being partially stripped away from coarse aggregate pieces by the washing action of water during the drilling operation. This material is found in approximately 11% of the total length of the cores.

3. Loose Coarse aggregate.

These are coarse aggregate pieces of the size and shape found in sound concrete, but not bound together by mortar. The aggregate is primarily clean, although mortar does coat some pieces. This material is found in approximately 9% of the total core length.

4. Fine, cementitious material.

This is a very fine material with a layered, silt-like appearance. The presence of at least some portland cement is indicated by its color and smell. Although cemented together sufficiently to be recovered intact by core drilling, this material readily disintegrates under finger pressure. It is noticeably less dense than the sound concrete encountered in these cores. This fine material is occasionally found in combination with either fine or coarse aggregate, but it is usually observed with no other material present. Approximately 9% of the total length of the cores contains this fine material.

5. Unrecovered material.

About 10% of the length of these cores is unrecovered. These unrecovered sections may represent void spaces in the tremie block, pockets of loose, uncemented fine aggregate which washed out of the drill barrel during the coring, or a combination of the two.

C. Cores Drilled by NYSDOT Personnel.

Eighteen full depth cores were drilled by the Main Office and Regional Soils personnel in September and October, 1979. These cores were taken from a widespread sampling of locations in the tremie. The diagram in Appendix D shows these locations.

As was the case with the previous cores, all eighteen NYSDOT cores encounter a variety of materials and include unrecovered portions. Appendix F contains the core logs for these cores. Appendix H contains core photographs.

The materials observed by inspection of the cores fall into the same categories as described in Section B above.

1. Sound Concrete.

This material occurs in approximately 50% of the total length of the eighteen cores.

2. Concrete with deficient mortar paste.

This material occurs in approximately 8% of the total core length.

3. Loose coarse aggregate.

This material is found in approximately 8% of the total length of the cores.

4. Fine, cementitious material.

This material is found in about 11% of the total core length.

5. Unrecovered material.

Approximately 23% of the total core length is unrecovered. Attempts were made to account for the significant core lengths for which no material was recovered. Two holes (DH-E and DH-F) were inspected with a borehole television camera. One other hole (DH-I) was sampled with a split spoon sampler in an area where no material was recovered.

The television camera did not locate any large voids, but it did locate broken up sections with small voids. The spoon sampler retrieved a mixture of fine aggregate material and what appears to be partially hydrated cement. These findings strengthen the possibility of there being relatively little void space inside the tremie. These findings indicate that most of the unrecovered lengths of core represent areas of loose fine aggregate.

D. Miscellaneous Material.

During subsequent drilling of the original tremie concrete related to the tremie footing corrective work material was recovered and forwarded to the Materials Bureau for evaluation and testing. The material consists of two large pieces (the larger approximately 9"x6"x4") composed of the same fine, cementitious material previously found in the cores. The pieces exhibit a fine layered structure, indicating that the material may have settled out of still water in approximately horozontal layers.

IV. TESTING

All material available for investigation underwent petrographic examination and physical and chemical testing. The test results are summarized and discussed in this section; the complete test results are presented in the Appendices as indicated.

The test results provide more detailed information about the tremie constituents and allow conclusions to be drawn regarding the soundness, strength and suitability of the material placed.

A. Project Concrete Cylinders.

1. Plastic testing records.

The plastic testing performed on the concrete at the project site during the pour included measurements of slump and air content. These test results show that the concrete slump and air contents, measured at the point of truck discharge, fell within specification limits (see Appendix C)

2. Compressive strength.

The average 28-day compressive strength for the ten cylinder pairs cast during the pour is 4375 psi. This compressive strength is typical for sound concrete obtained from this mix. The strengths are shown in Appendix C.

3. Unit Weight.

The average unit weight of the 10 cylinder pairs cast was found to be 145.8 lbs. per cubic foot. This is not a dry unit weight, as the cylinders were curing in the 100% relative humidity environment just prior to measurement. The measured unit weights are shown in Appendix C.

The unit weight of cast concrete cylinders indicates the density which can be expected from concrete supplied to the job, assuming proper placement and consolidation. The unit weight for these test cylinders is typical for concrete incorporating the cement content, fine and coarse aggregates and air content specified by the Class G mix design.

B. Core Specimens.

Specimens were selected from the two sets of cores obtained from the tremie. The specimens selected enable comparisons to be made of the petrographic, physical and chemical properties of the various tremie materials. The specimens selected also give a sampling of materials located throughout the tremie.

1. Petrographic examination.

Two core specimens were sliced longitudinally and polished to permit microscopic examination. One specimen (core DH-C) was selected from sound concrete and the other (core DH-M) from a section of concrete with deficient mortar paste. Photographs of these specimens are in Appendix J.

The polished sections show striking differences in internal structure. The sound concrete has good distribution of fine and coarse aggregate throughout its mortar paste. The paste is sound, contains entrained air and is free of any visible distress. In contrast, the deficient mortar paste section has a deficiency of fines and paste, with coarser aggregate particles predominating. The paste that is present has little entrained air, and fine cracking indicates the paste lacks the strength of that found in sound concrete.

The deficiency of fines and paste in the weakened concrete specimen can be accounted for by segregation of the mix during placement. The substantial amount of fines and cementitious material found elsewhere in the tremie strenghtens the likelihood that extensive segregation did occur during placement. The continuous inspection, sampling and testing of the concrete throughout the pour make it extremely unlikely that the concrete supplied to the project originally had these deficiencies.

2. Compressive strength.

Several core samples of the various materials in the tremie were tested for compressive strength. The test results are shown in Appendix L.

The test results indicate substantial differences in the compressive strengths of the sound concrete, the concrete with deficient mortar, and the fine cementitious material. The sound concrete has considerably higher compressive strength (a 12 sample average of 5508 psi) than the other materials. The concrete with the deficient mortar has the next highest compressive strength (3 sample average, 1400 psi) and the fine cementitious material has the lowest compressive strength (6 sample average, 540 psi).

These test results confirm the relative strengths expected from the appearance of the different tremie materials. Fairly wide ranges of compressive strengths exist for each material. These can be explained largely by the nonuniformity of the tremie materials. The spreads can also be accounted for in part by changes in age and moisture content the specimens experienced before testing.

The compressive strengths of the sound concrete specimens reasonably compare with the 28-day concrete cylinder strengths and the compressive strength expected of the mix.

3. Unit weight.

The unit weights of samples of the various materials were measured.

Appendix M lists these unit weights.

There are striking differences in the unit weights of the various materials. The sound concrete is the most dense (11 sample average, 142.1 pounds per cubic foot), followed by the concrete with deficient paste (three sample average, 130.1 pcf). The fine cementitious material is only approximately half as dense as sound concrete (eight sample average, 63.2 pcf). The lightweight property of this material became quite evident during the unit weight determination when samples actually floated in water.

The unit weights of the sound concrete specimens are consistent and are comparable to project concrete cylinder unit weights. The unit weights of the concrete with deficient mortar show variations which can be expected from a nonuniform material, but also indicate the unit weight of this material is relatively close to the unit weight of sound concrete. The greatest variations in unit weight occur in the fine cementitious material, but even the most dense specimen of this material is considerably less dense than sound concrete. The nonuniformity of materials as placed in the tremie can account for most of the observed unit weight variations.

4. Air content.

Several core samples were tested for air content. The test results are tabulated in Appendix N.

The Department's high pressure air meter was used to obtain the total air content. The total air content includes both entrained and entrapped air.

The test results indicate that the total air content for sound concrete in place is 3.6% by volume, and 2.6% by volume for the concrete with deficient mortar paste. The total air content for the fine cementitious material is extremely high, exceeding 60% by volume. The tests indicate that sound concrete lost approximately 1% air from the point of truck discharge to the point of placement. The lower air content in concrete with deficient paste can be accounted for by the lower cement paste content for this material The excessively high air content of the fine cementitious material is consistent with its low unit weight.

5. Grain size analysis.

A sample of the fine cementitious material was hand pulverized and a gradation run on the resulting material. The sample was not mechanically pulverized as it was feared this would break down individual particles and give a false indication of grain sizes. The gradation is tabulated in Appendix O.

The hand pulverization resulted in a substantial portion of very fine particles (42.1% by weight, passing the #400 sieve). Almost all the remaining material is retained on the #200 sieve. Examination of this material shows that further disintegration into finer particles is possible, indicating that the coarser particles are actually smaller particles cemented together. Thus the fine cementitious material is most likely very fine material almost entirely passing the #400 sieve. Portland cement powder exhibits this degree of fineness.

6. Chemical analysis.

Samples of the fine cementitious material were tested against the chemical requirements for Type 2 Portland Cement. The specification requirements and test results are shown in Appendix P.

The fine material meets the requirements for silica, alumina, magnesia and sulphur dioxide content, is slightly under the minimum content specified for iron oxide and has a substantially lower lime content than expected for a Type 2 cement. The material considerably exceeds the maximum limits for loss on ignition and insoluble residue. This chemical analysis shows enough conformity with the chemical requirements of Type 2 portland cement to indicate that cement comprises a substantial portion of the fine cementitious material. The high loss on ignition and insoluble residues indicate partial hydration of the cement and the presence of some fine, noncementitious material.

V. DISCUSSION

A model of the internal structure of the tremie has been developed, using the cores extracted from the tremie as a guide. Longitudinal cross sections of this model are in Appendix Q.

The model indicates that a substantial part of the tremie does not consist of sound concrete. The model shows that the tremie is a nonhomogeneous mass, made up of layers and lenses of loose stone, fine cementitious material, loose fine aggregate and concrete with deficient paste sandwiched in and around sound concrete.

Some constituents appear to be concentrated in specific areas of the tremie. The fine cementitious material occupies a considerable volume in the south half of the tremie. Lenses of loose coarse aggregate are distributed throughout the tremie, with their greatest concentration in the center and towards the north end. The substantial unrecovered lengths of core are located in the center of the block and also in the vicinity of the fine cementitious material, making it likely that large volumes of loose fine aggregate are located in these areas.

Approximate volumes of the total tremie block and its individual constituents were computed. The computations indicate the total tremie placement volume is 2033 cubic yards, which is close to the Engineer's estimate of 2023 cubic yards. Of this total volume, approximately 234 cu. yd. (or 11.5%) is fine cementitious material; 113 cu. yd. (or 5.6%) is loose coarse aggregate; and 327 cu. yd. (or 16.1%) is primarily loose fine aggregate with some small voids and coarse aggregate materials possibly present.

Sound concrete and concrete with deficient paste occupy the remaining two-thirds of the tremie volume. Approximately 85% of this combined volume is sound concrete. The two components were consolidated together to simplify the model and the computations.

The concentration of low density material near the south face of the tremie explains why the tremie block lifted there. With so much low density material present, the average unit weight of the tremie in this area decreased to the point where the uplift forces common to any placement of this type could no longer be resisted. Appendix S tabulates the average unit weight of the material in sections of the tremie, and equates the mass of material in each section to the height of sound concrete providing equivalent resistance to uplift. Note that the lowest average unit weights and equivalent heights are in the south half of the tremie.

The large volumes of low density material present in the tremie also explain why only approximately 1700 cubic yards of concrete were needed to fill a 2000 cubic yard volume. The average equivalent height of sound concrete over the entire tremie model is computed to be 11.5 feet. This means that a volume of only approximately 1748 cubic yards of sound concrete of normal density provides the mass equivalent to the mass computed to be in the 2033 cubic yard tremie model. Extensive segregation of materials is necessary to account for such a difference in volumes.

The observations of project personnel appear to confirm that such extensive segregation occurred during the pour as a consequence of the method of placement selected by the Contractor. The cofferdam was clean and free of debris (silt, broken rock, etc.) at the start of the tremie pour. Nothing found in any of the cores indicates the presence of any debris. All material found in the cores appears to consist of material originating in the concrete mix used to pour the tremie.

The method of placement created conditions that contributed to segregation of the mix. The steep (1:3 and steeper) exposed faces of placed concrete allowed fresh concrete to flow through water and segregate into its components; paste, fines and coarse aggregate. The numerous breaks of the seal between fresh and previously placed concrete allowed subsequently placed concrete to flow directly from the tremie tube into water, encouraging segregation.

The location of the materials found in the tremie concrete can be explained by segregation of the mix during placement. The pour began in the northeast corner of the cofferdam and generally progressed towards the south face. If segregation was occurring, material could be expected to be carried in water suspension just ahead of the concrete materials previously deposited. The largest particles (coarse aggregate) settled out soon after they were in suspension, followed by finer material (fine aggregate). The finest material (cement paste) settled out last. As the pour continued, the finest material was pushed ahead until the south cofferdam face prevented any further horizontal movement. Subsequent concrete placement trapped this material. Similar pockets of fine and coarse aggregate are found in other sections of the tremie. Where the mix is not completely segregated, the concrete has a cement paste deficiency and that paste is weakened by the disturbances that occurred during placement.

The extensive mix segregation definitely could have been avoided. The method of placement chosen assumed mix flow characteristics that approach or exceed the optimum flow characteristics that can be expected from concrete under extraordinary conditions. Achieving such optimum flow requires a special mix with unusually high flow properties.

The Department's Class G mix is the mix routinely specified for underwater placements. This mix has repeatedly demonstrated its ability to be satisfactorily placed underwater, having been used on numerous projects throughout the State without serious difficulty. As for any concrete mix, proper consideration of flow characteristics is essential for successful placement underwater by tremie. The Contractor did not exercise such proper consideration here and attempted a placement requiring flow characteristics greatly exceeding mix limitations.

The method of placement also must conform to commonly accepted construction practices to maximize the likelihood of success. These practices are found in detail in numerous literature dealing with concrete construction. The section of the Standard Specifications relevent to underwater concrete placements (Section 555 - 3.05, Depositing Structural Concrete Under Water) refers to these requirements.

The placement procedure used for this project apparently violated specification requirements. The most serious violations were that the concrete was not deposited in horizontal layers and that the discharge end of the tremie tube was not sealed in previously placed concrete at all times. The method of placement was also not in conformance with commonly accepted construction practices, as the lack of additional tremie tubes and the inadequate concrete delivery system demonstrate.

VI. CONCLUSIONS

Examination of tremie material samples, data from tests performed on these samples and consideration of the model of the tremie's internal structure leads to the conclusions enumerated in this section.

A. Concrete supplied to the project.

1. The concrete supplied to the project for the east pier tremie was produced at a Department approved and inspected plant.

2. The concrete incorporated portland cement, fine and coarse aggregates and admixtures which were all approved by the Department.

3. The concrete was produced according to a Department approved mix design.

4. The concrete incorporated into the tremie met the specification requirements for plastic concrete.

5. The project cylinder testing demonstrated the capability of the concrete to meet specification requirements for strength and soundness.

6. The concrete was capable of achieving satisfactory strength and soundness when placed by tremie methods, providing proper placement procedures were employed, as has been demonstrated on numerous Department projects.

B. Composition of the tremie.

1. All material in the tremie originated in the concrete deposited into the cofferdam.

2. There is no evidence of silt or any other foreign debris present in the tremie.

3. A substantial volume of the tremie (approximately 55%) consists of apparently sound concrete.

4. There is extensive segregation of the concrete mix throughout the tremie block.

5. The segregated materials appear in the following forms: concrete with a deficient mortar paste; loose coarse aggregate; loose fine aggregate; and a fine cementitious material.

6. There are no extensive voids present in the tremie. Small voids do exist, but collectively they appear to occupy only a small portion of the total volume.

7. Although segregated material is encountered throughout the tremie, individual segregated components tend to be concentrated in specific sections. The fine cementitious material is limited primarily to the south half of the tremie. Loose fine aggregate is found primarily in the center and towards the south end, and loose coarse aggregate is primarily in the north half of the tremie.

C. Properties of tremie constituents.

1. The sound concrete has the density, durability and strength that can be expected from concrete containing acceptable quality materials, properly mixed and placed.

2. The concrete with deficient mortar paste lacks the soundness and strength characteristic of the quality concrete that can be obtained with this mix. This concrete has less paste and fines than sound concrete. The paste that is in this concrete exhibits cracking and other distress which can affect concrete durability.

3. The loose coarse aggregate is characteristic of the coarse aggregate used in the mix.

4. The loose fine aggregate is characteristic of the fine aggregate used in the mix. The small amount of cement that is mixed in with this material is insufficient to create a cementitious mass.

5. The fine cementitious material consists of a mixture of partially hydrated portland cement and other fines. This material is only approximately half as dense as sound concrete and lacks the strength, soundness and durability of sound concrete.

6. The extensive segregation of the concrete mix during placement and the relatively low unit weights of the segregated materials as placed caused a much smaller mass of concrete than anticipated to be capable of filling the total volume of the tremie. If the concrete had not segregated during placement, an additional, approximate 300 cubic yards of concrete would be needed to completely fill the total volume.

D. Causes of concrete segregation.

1. The method of concrete placement chosen by the Contractor is the decisive factor that caused the extensive mix segregation. Concrete was placed with only one tremie tube for the entire cofferdam area. This method of placement depends on extraordinary mix flow characteristics to be successful. The Contractor assumed underwater flow characteristics that are unreasonable to expect from the Department's specified mix.

2. The method of placement chosen for this mix was unsuccessful because it resulted in a steeply inclined unrestrained face of placed concrete. Newly placed concrete flowed down this face, causing suspension of material in water and, upon settlement, material segregation. As the pour progressed, the volume of these segregated materials increased.

3. The frequent breaking and reestablishment of the tremie seal was a contributing factor that helped cause the extensive mix segregation. This frequent breaking of the seal and the cumbersome, time consuming efforts required to reestablish the seal were made inevitable by the Contractor's chosen method of placement and the equipment he elected to use for the placement. This frequent breaking of the seal is in violation of the specifications.

4. The method of placement chosen by the Contractor is inconsistent with recommended construction practices for tremie placements as defined by commonly recognized references.

VII. <u>RECOMMENDATION</u>

The recommendation of the Technical Services Subdivision is consistent with the preliminary recommendation of October 3, 1979. The tremie, with its extensive material segregation and unfavorable evaluation as a structural load bearing member, cannot be relied upon for support of the structure.

As a consequence of this recommendation, remedial actions were taken to correct the tremie footing deficiencies. Information regarding the design and progression of the repairs can be obtained from the appropriate Departmental sources.

APPENDIX A

October 3, 1979

D96103; PIN 1700.18.325
TROY-GREEN ISLAND BRIDGE
EAST PIER TREMIE POUR

ORIGINAL SIGNED BY
WM. P. HOFMANN

Wm. P. Hofmann, Tech. Serv. Subdiv., Rm. 210, Bldg. 7A

E. V. Hourigan, Structures Subdiv., 6th Flr., Bldg. 5

cc J. Sternbach, Construction Subdiv., Rm. 423, Bldg. 5
C. E. Carlson, Regional Director, Region 1
L. H. Moore, Soil Mechanics Bur., Rm. 102, Bldg. 7
J. J. Murphy, Materials Bureau, Rm. 210, Bldg. 7A
L. W. Hallenbeck, Chief Engineer, Rm. 401, Bldg. 5

Here is a preliminary report of the work conducted to date by this Subdivision to determine the condition of the tremie concrete in the east pier of this project.

The Materials Bureau inspected and tested eleven cores drilled from the tremie block by the Contractor. These cores show that the tremie block contains an extensive amount of sound concrete, but also that there are significant pockets of concrete with weakened mortar, loose coarse aggregate and unidentified fine material. Further, unrecovered portions of the cores indicate the possible presence of pockets of loose fine aggregate, void pockets, or a combination of the two.

The Materials Bureau performed a number of preliminary tests on selected core specimens. The tests include unit weight determination, compressive strengths and grain size analysis and chemical analysis of the unidentified fine material. Examination and testing of the project concrete cylinders was also performed by the Materials Bureau.

The tests indicate that the sound concrete encountered in the tremie block is of good quality (unit weight 145 pcf and compressive strength approximately 5200 psi). The tests also indicate that the fine material has a density considerably below (approximately 83 pcf) the density of sound concrete, has a low compressive strength (approximately 100 psi) and will readily deteriorate if exposed to scouring action. There is a good possibility that this fine material, which occupies a considerable volume towards the south end of the pier, is a mixture of partially hydrated portland cement and other fines.

These observations and tests all indicate that there is extensive material segregation in the tremie block and that much of the segregated material is of highly questionable load bearing capacity.

Preliminary Recommendations

The unfavorable evaluation of the tremie block material as a structural load bearing member together with evidence of extensive material segregation and possible voids leads to a recommendation that the tremie not be relied upon for support of the structure.

The Soil Mechanics Bureau recommends that a caisson design be progressed for the east pier. This design can be similar to that used at the west pier except that smaller diameter caissons, if used, will require deeper sockets.

Rock anchors designed to pretest the load carrying capability of the tremie block are not recommended because of the block's deficient condition. In addition, the anchors' cost would probably equal or exceed a caisson design even if the tremie block was considered structurally adequate.

Representativesof the Soil Mechanics Bureau will, as usual, work with the Structures Subdivision on this design concept or any others that have merit.

This concludes our preliminary report. Work necessary for the preparation of the final report is currently under way. We will transmit our final report on the structure to your office when we have completed that work.

WPH:RC:FS
File: 12.2

APPENDIX B

PROJECT CONCRETE DATA

GENERAL INFORMATION:

Date of Pour: 8/27-8/28/79
Class: G, Item 555.06
Plant: Clemente - Latham, Troy, N.Y.
Concrete System: Central Mix
Cement: Independent - Kingston, Type II
Fine Aggregate: Valente Gravel, Inc., Troy, N.Y. Source 1-63F
Coarse Aggregate: Fitzgerald Bros. Const. Co., Troy, N.Y. Source 1-7R
Air Agent: MBVR
Retarder: Plastiment

MIX DESIGN DATA

CLASS	PLANT/LOCATION	FM	SGPC	SGFA	SGCA	PC1	PC2	PC3
G	CLEMENTE-LATHAM	3.20	3.15	2.63	2.69	50	50	0

BATCH QUANTITIES
(CUBIC YARD)

CEMENT (LBS)	685
WATER (LBS)	308
SAND (LBS)	1131
#1 CA (LBS)	868
#2 CA (LBS)	868
#3 CA (LBS)	0
W/C RATIO	0.45
AIR CONTENT (%)	5.0
SLUMP (INS)	7.0-8.0
UNIT WEIGHT (PCF)	142.93

NOTES:
1) ALL AGGREGATE IS ASSUMED TO BE IN A SSD CONDITION. ADJUST BATCHING WEIGHTS TO MAINTAIN CORRECT PROPORTIONS AS FREE MOISTURE VARIES. (USE TABLE BELOW FOR SAND AND COARSE AGGREGATES. ADDED WATER SHOULD BE ADJUSTED TO COMPENSATE FOR FREE MOISTURE.)
2) ROUND SCALE WEIGHTS AS REQUIRED BY BATCHING EQUIPMENT.

APPENDIX C

PROJECT CONCRETE TEST DATA

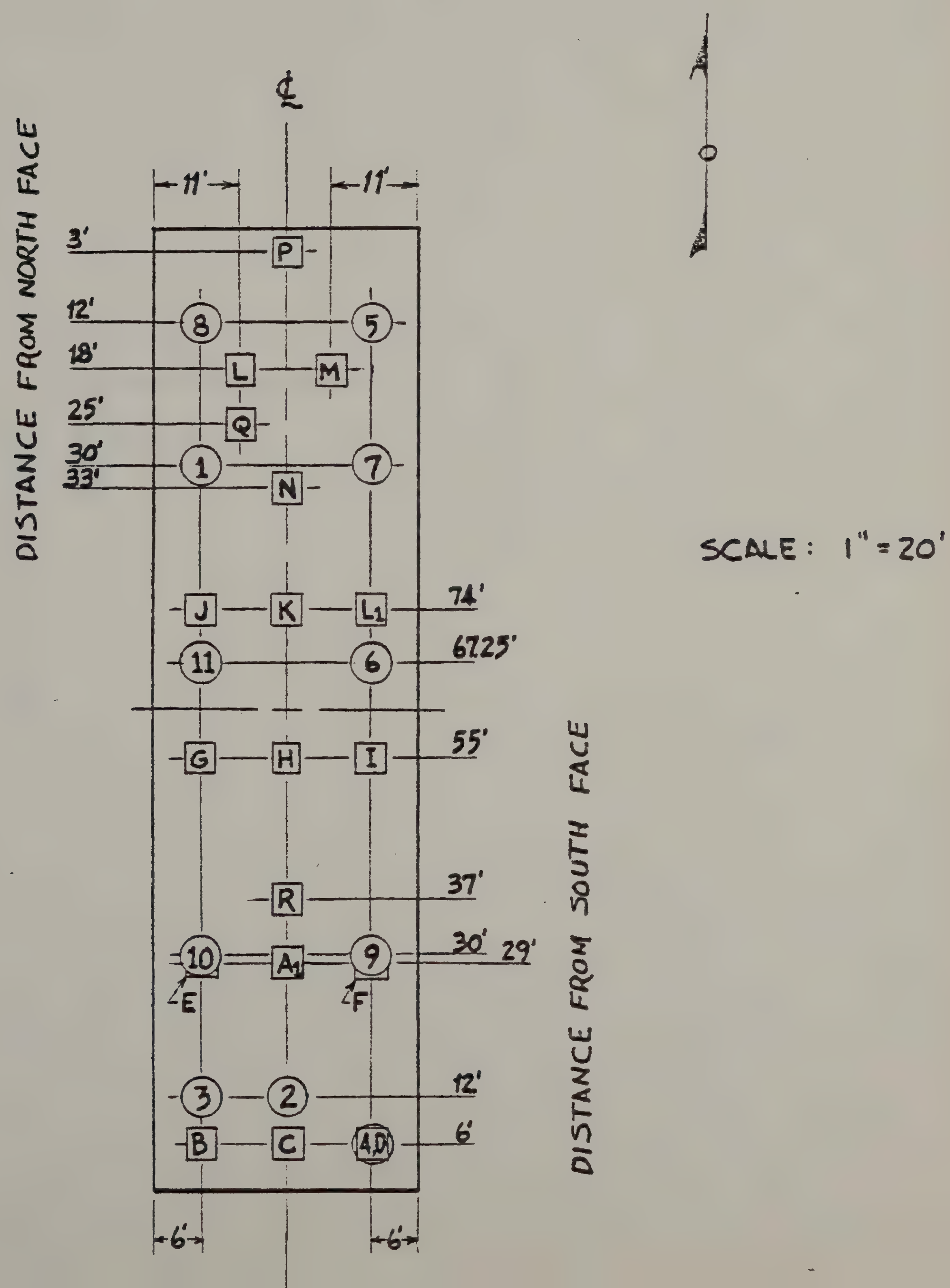
TEST REFERENCES:
Compression: 79 SK 2288-2297, 9/24-9/25/79
Unit Weight: 79 SD 428-447, 9/20/79

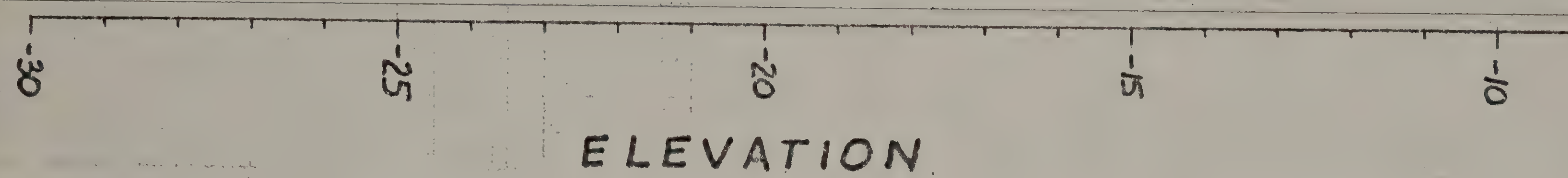
CYLINDER	DATE/TIME CAST	SLUMP(in)	AIR(%)	UNIT WEIGHT (lbs/cu.ft.)	28 Day COMPRESSIVE STRENGTH (PSI)
20 C	8/27-1120	7.5	4.5	147.34	4520
20D				146.22	4510
21C	8/27-1530	7.0	4.5	144.39	4410
21D				145.00	4310
22C	8/27-1800	7.0	5.5	146.37	4200
22D				144.69	4410
23C	8/27-2215	7.75	6.0	143.82	4790
23D				144.28	4720
24C	8/28-0230	8.0	4.6	145.00	4440
24D				145.20	4640
25C	8/28-0615	7.25	6.2	143.72	3980
25D				142.30	4220
26C	8/28-1018	7.0	3.8	146.88	4120
26D				147.75	4250
27C	8/28-1330	8.0	3.7	146.12	4070
27D				145.76	4080
28C	8/28-1915	8.0	4.3	147.80	4520
28D				147.95	4500
28K	8/28-1430	7.0	3.2	147.75	4620
28L				147.95	4200
Average		7.5	4.6	145.81	4375

APPENDIX D

TROY - GREEN ISLAND BRIDGE

EAST PIER TREMIE
TEST CORE LOCATIONS

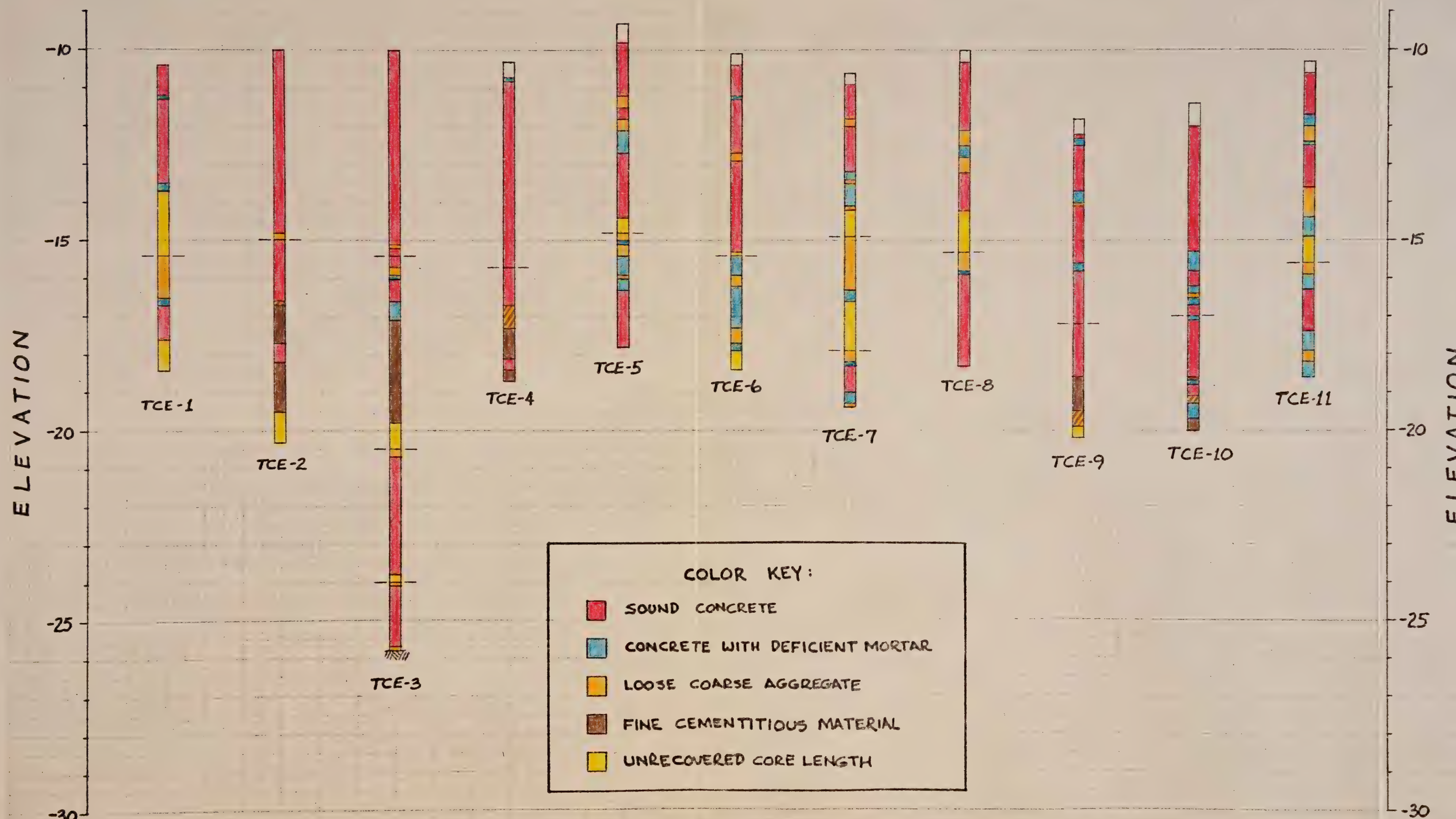


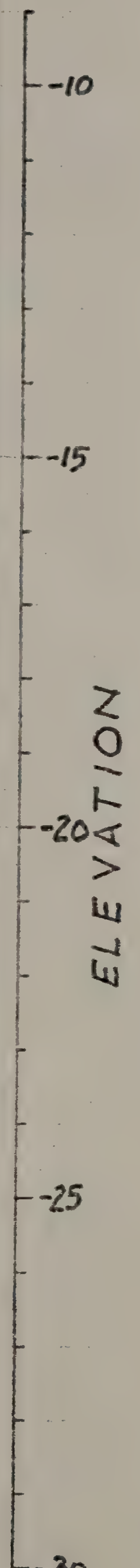

-30
-25
-20
-15
-10
ELEVATION

APPENDIX E

TROY - GREEN ISLAND BRIDGE — EAST PIER TREMIE CONCRETE — CORES TCE-1 THRU TCE-11

CORES DRILLED BY EMPIRE SOILS INVESTIGATIONS, INC.

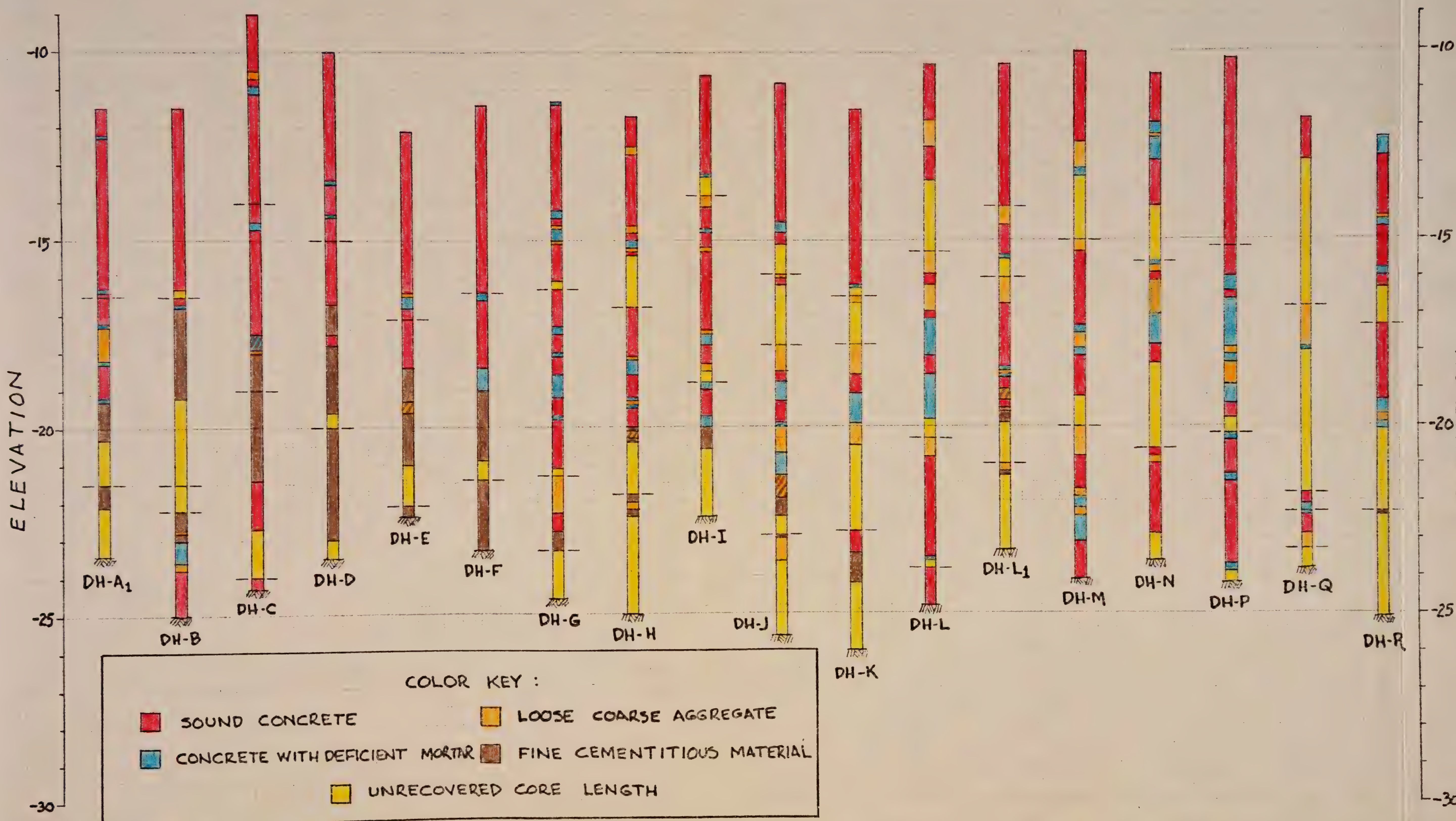



-10
-15
-20
-25
-30
ELEVATION

APPENDIX F

TROY - GREEN ISLAND BRIDGE — EAST PIER TREMIE CONCRETE — CORES DH-A_1 THRU DH-R

CORES DRILLED BY NYSDOT SOILS PERSONNEL

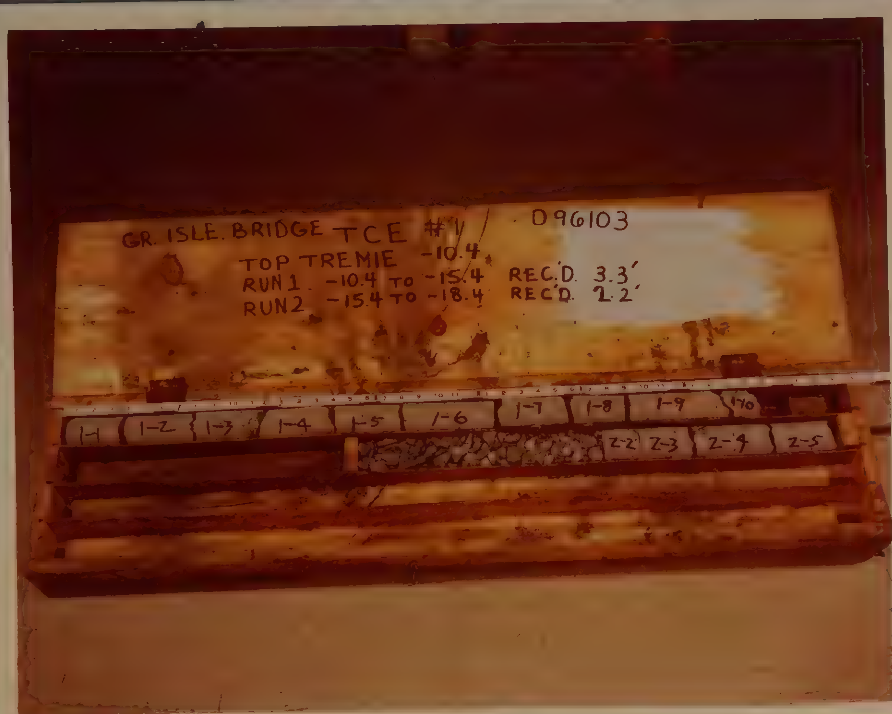


APPENDIX G

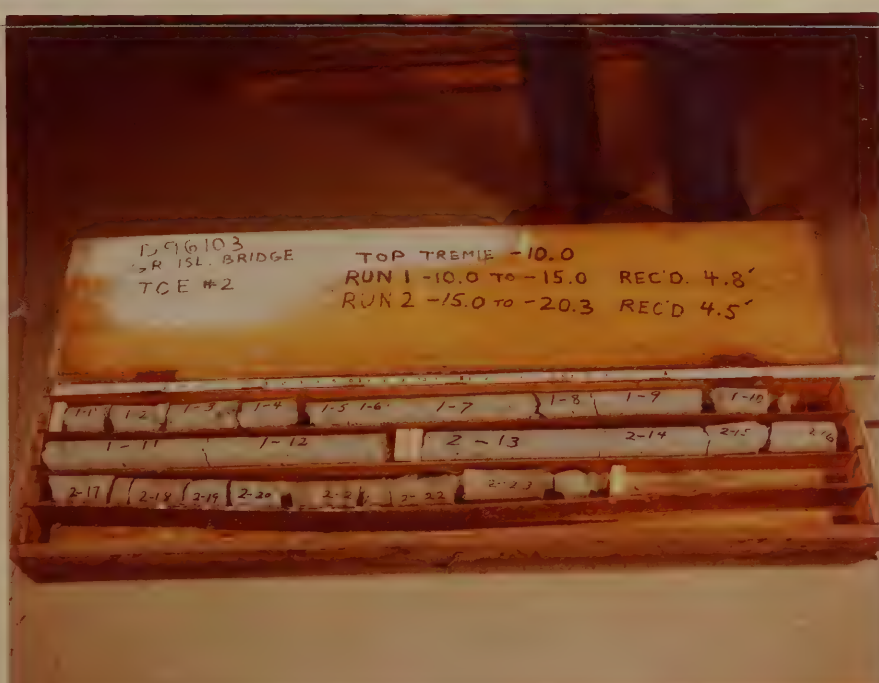
CORE PHOTOGRAPHS

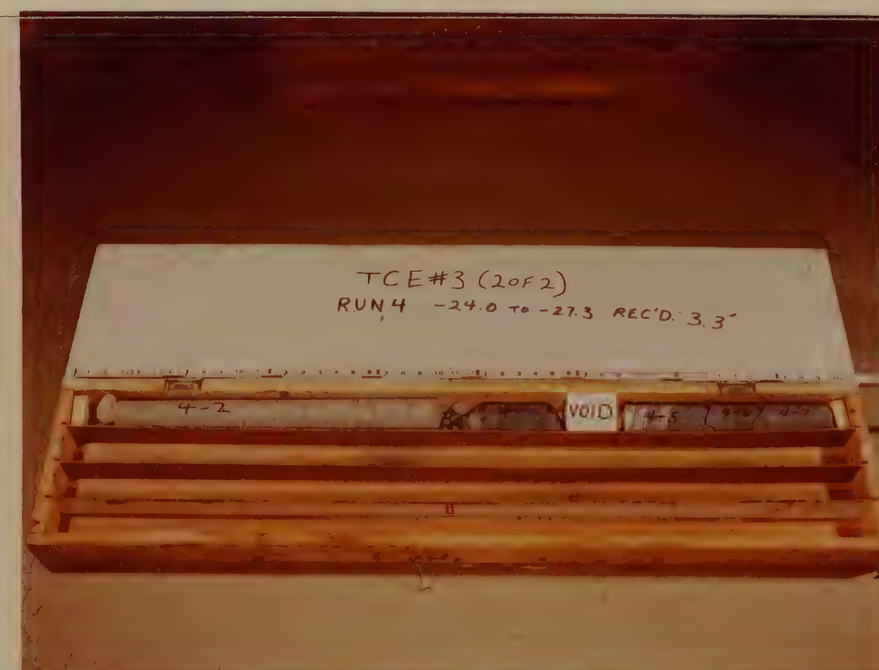
CORES DRILLED BY

EMPIRE SOILS INVESTIGATIONS, INC.


GR. ISLE. BRIDGE TCE #1 / D96103
TOP TREMIE -10.4
RUN 1 -10.4 TO -15.4 REC'D. 3.3'
RUN 2 -15.4 TO -18.4 REC'D. 2.2'

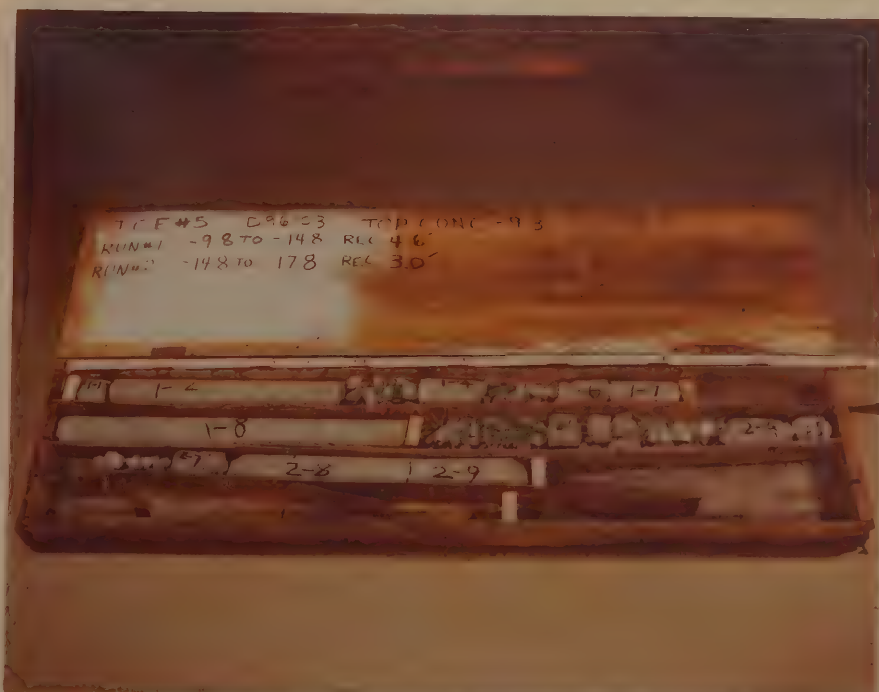

GIB. D96103 TCE #3
TOP CONC. -10.0
RUN 1 -10.4 TO -15.4 REC'D. 5.0'
RUN 2 -15.4 TO -20.5 REC'D. 4.4'
RUN 3 -20.5 TO -24.0 REC'D. 3.1'
*RUN 4 -24.0 TO -27.3 REC'D. 3.3' *SEE BOX 2 OF 2
2-9
TESTED IN LABORATORY
TCE 3


D96103
GR ISL. BRIDGE
TCE #2
TOP TREMIE -10.0
RUN 1 -10.0 TO -15.0 REC'D. 4.8'
RUN 2 -15.0 TO -20.3 REC'D 4.5'


TCE #3 (2 OF 2)
RUN 4 -24.0 TO -27.3 REC'D. 3.3'
VOID


G.I.B. D96103 TCE#4
TOP OF CONC -10.3'
RUN#1 -10.7' TO -15.7' RCE'D 5.0'
RUN#2 -15.7 TO -18.7 RCE'D 3.0'
1-7 TESTED

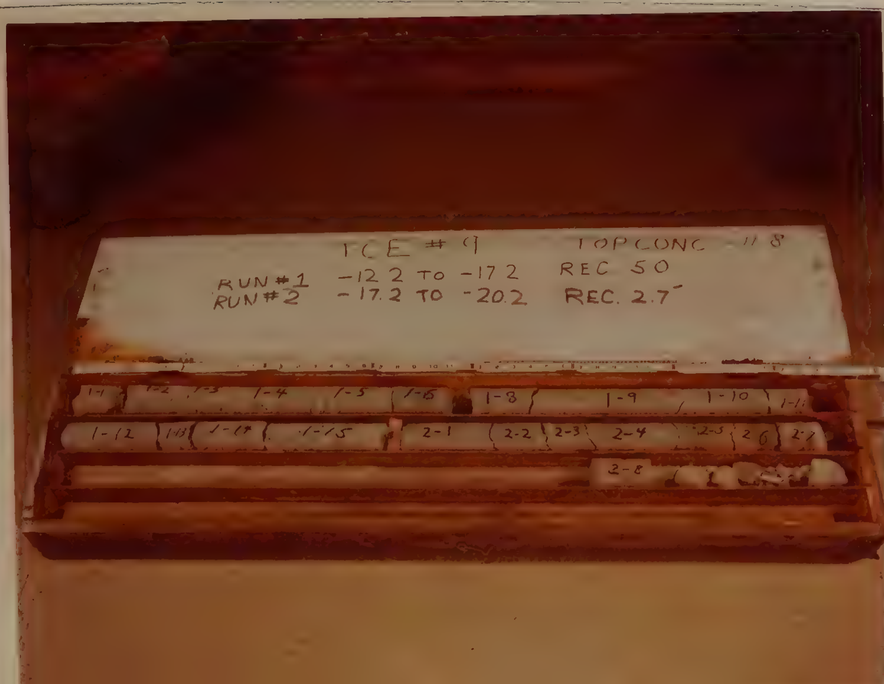

1-8 TESTED


RUN#1 -9.8 TO -14.8 REC 4.6'
RUN#2 -14.8 TO 17.8 REC 3.0'
1-8
2-8
2-9


RUN 2 -14.9 TO -17.9 REC'D 1.7'
3-3


ICE #8 TOP CONC -10.0
RUN #1 -10.3 TO -15.3 REC. 3.9'
RUN #2 -15.3 TO -18.3 REC. 3.0'


G.I.B. D96103 ICE # 10
TOP CONC -11.4
RUN 1 -12.0 TO -17.0 REC'D 5.0'
RUN 2 -17.0 TO -20.0 REC'D 3.0'


ICE # 9 TOPCONC -11.8
RUN #1 -12.2 TO -17.2 REC 5.0
RUN #2 -17.2 TO -20.2 REC. 2.7'

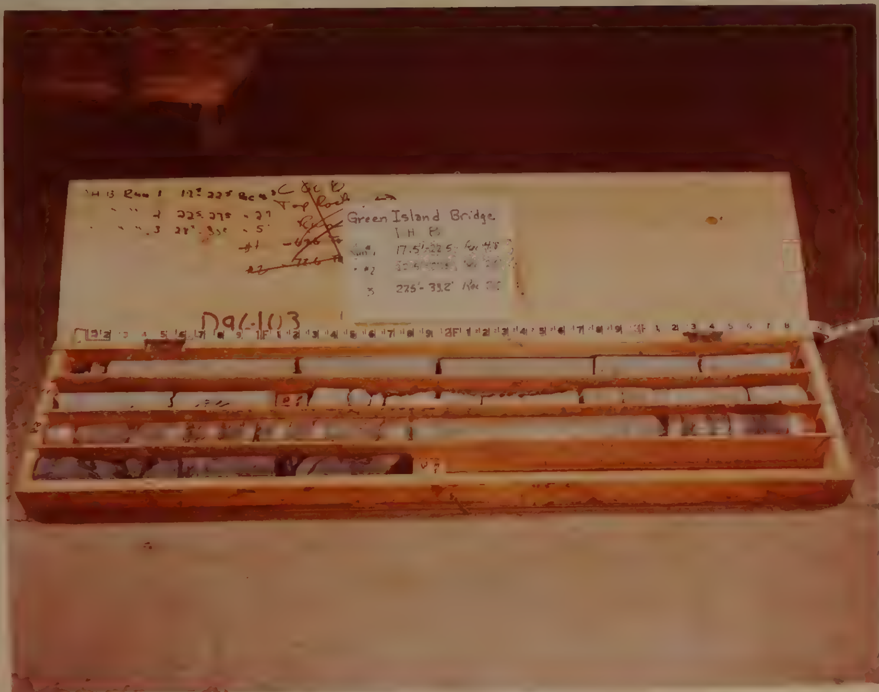

ICE 11
RUN 1 -10.6' TO -15.6' REC'D 4.3
RUN 2 -15.6' TO 18.6 REC'D

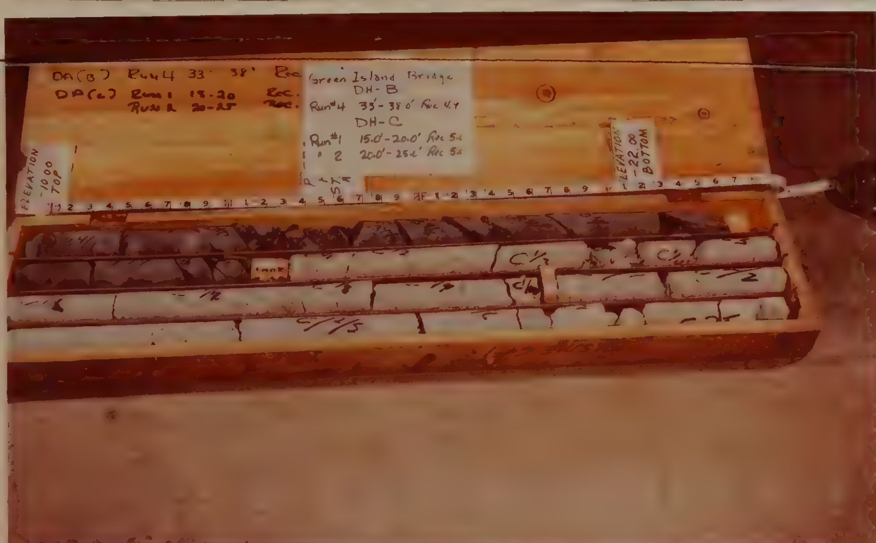
APPENDIX H

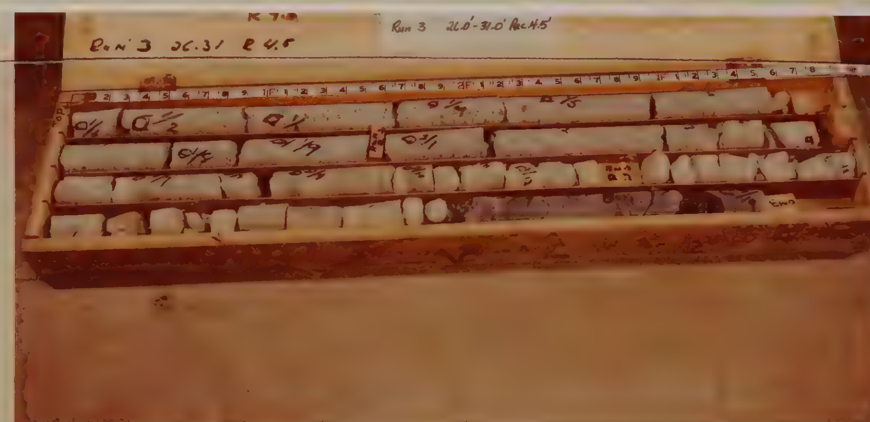
CORE PHOTOGRAPHS

CORES DRILLED BY

NYSDOT PERSONNEL

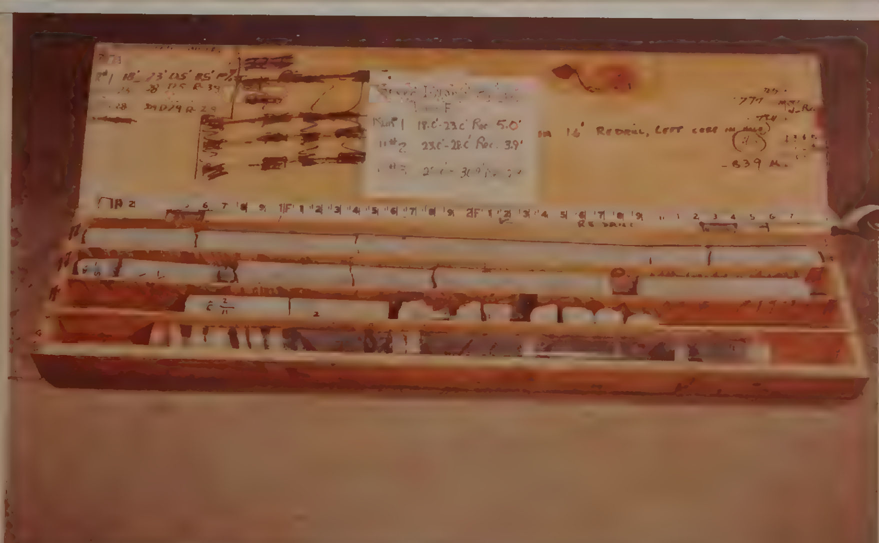

Green Island Bridge


Green Island Bridge
DH-B
DH-C
ELEVATION
-10.00
TOP
ELEVATION
-22.00
BOTTOM

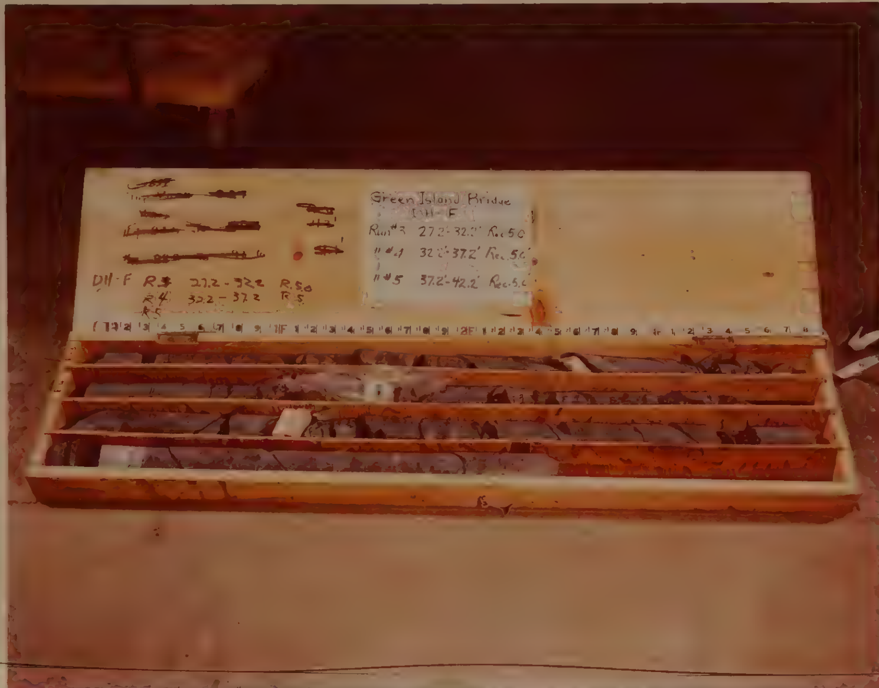

Run 3 26.0'-31.0' Rec 4.5'

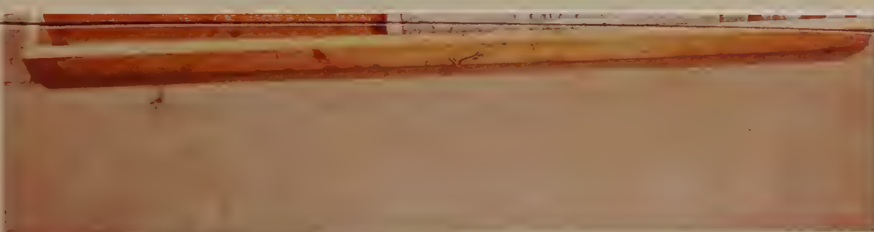
OH(D)
R#5 36. 41 Rec 5'

Green Island Brig



16' Redrill, left core in hole

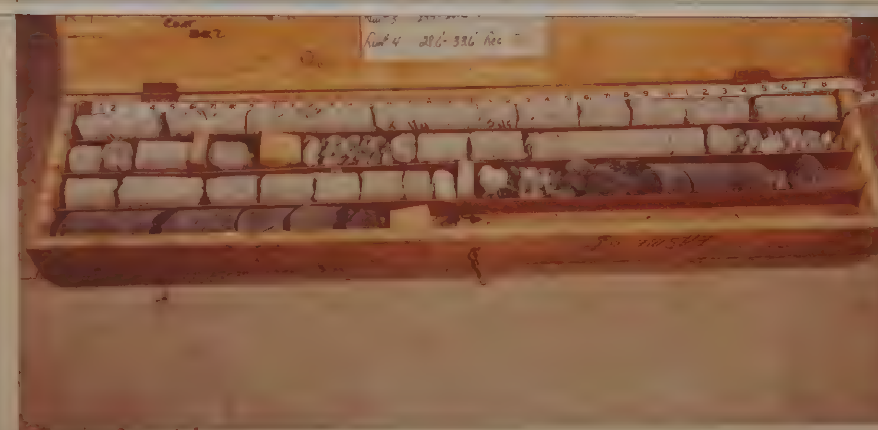

Green Island Bridge
DH-F
Run#3 27.2'-32.2' Rec 5.0
" #4 32.2'-37.2' Rec 5.0
" #5 37.2'-42.2' Rec 5.0
DH-F R3 27.2-32.2 R.5.0
R4 32.2-37.2 R.5
R5



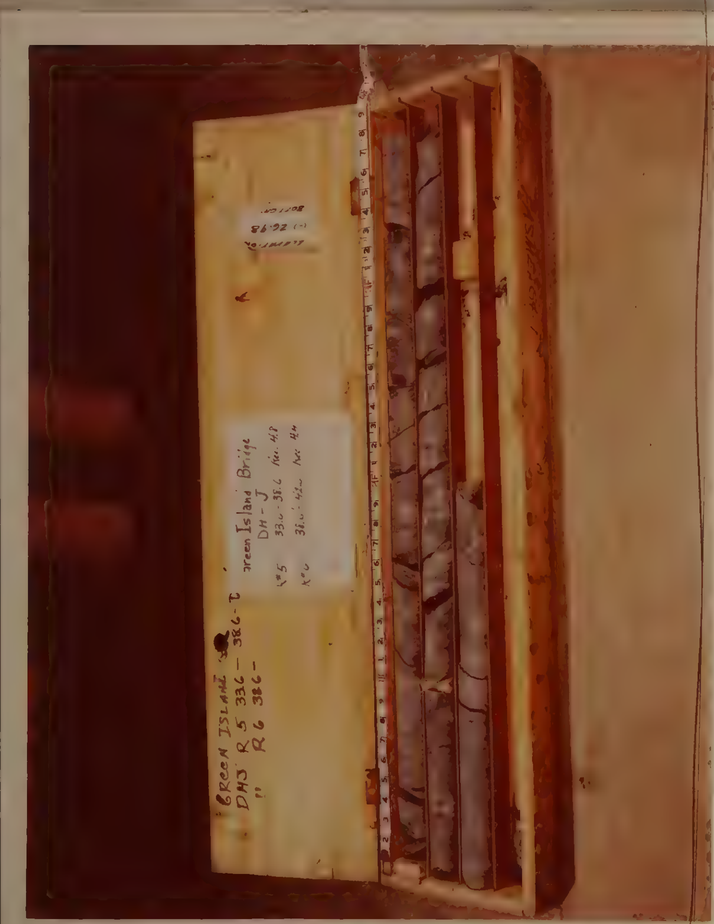

Green Island Bridge
DH-G
R#4 2.8'-33.0' Rec
R#5 33.0-38.5' Rec 5.0
R#6 38.5-43.5 Rec 5.0
33.5 38.5 D 5 - R - 5'
6 38.5-43.5-D5-R-5

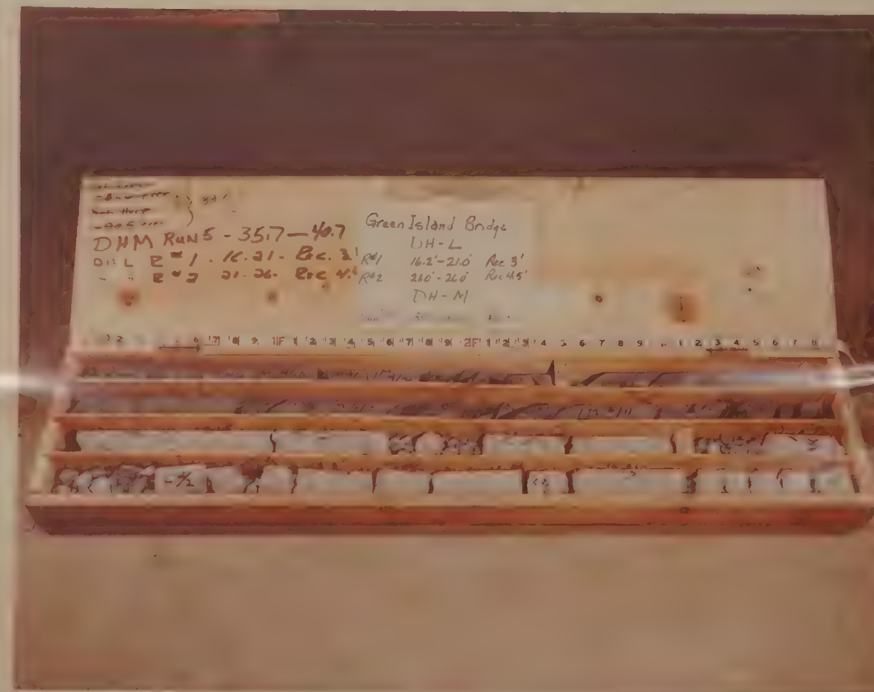

Top Rock - 83.5

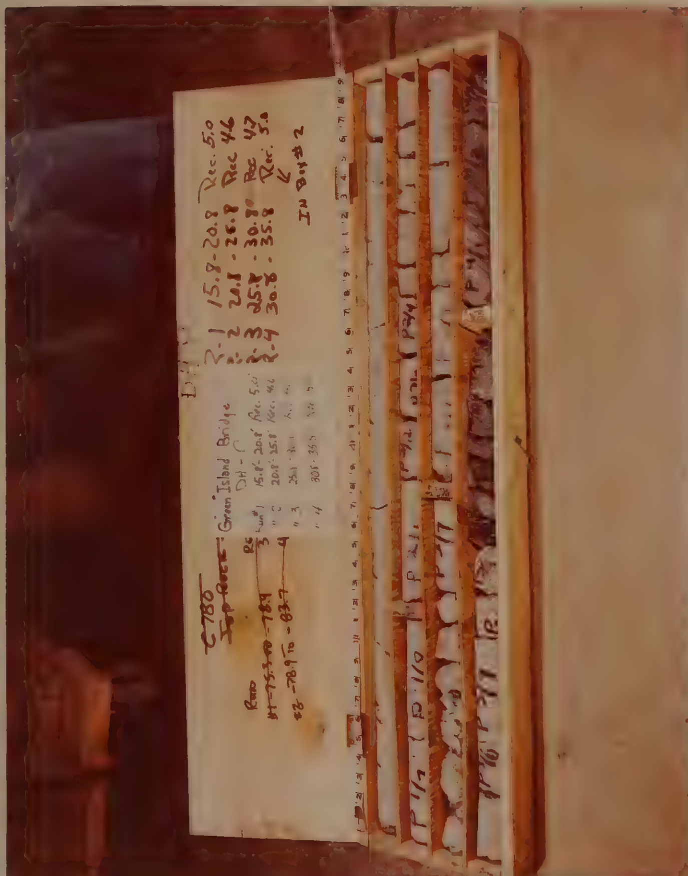

DHI GREEN INBOND BR
R-4 28.8 33.8 D.5 R4.8 96%
R.5 33.8- 37.1 D3.3 R3.3-100%
R6 37.1 40.2 D3.1 R3.1
DH - I
Run4 28.8'-33.8 Rec 4.8'


Run 4 28.8'-33.8' Rec

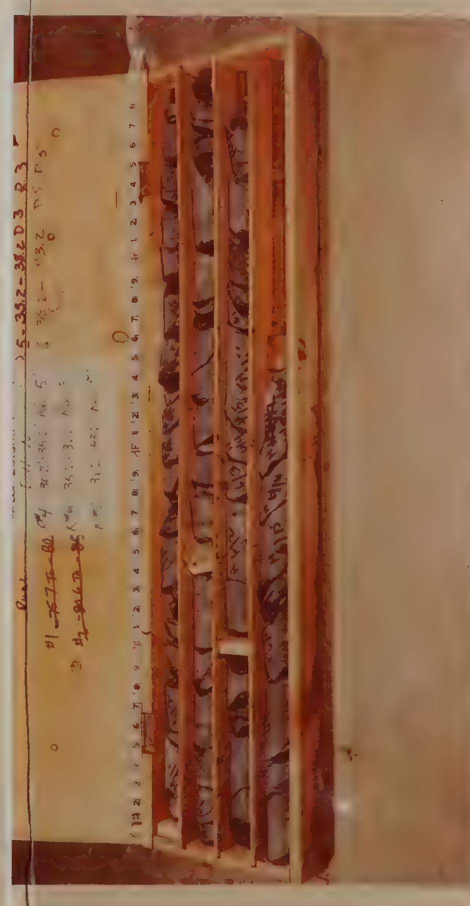

GREEN ISLAND BR
Green Island Bridge

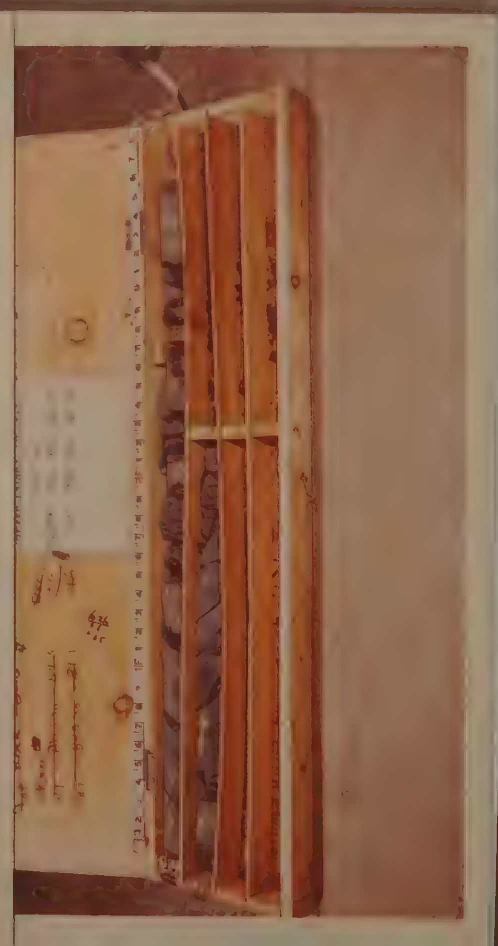

GREEN ISLAND
Green Island Bridge


DH-L
Run

DHM RUN 5 - 35.7 — 40.7
Green Island Bridge
DH-L
16.2'-21.0' Rec 3'
21.0'-26.0' Rec 4.5'
DH-M



PIECE RECOVERED DURING C[illegible]





APPENDIX I

FINE CEMENTITIOUS MATERIAL

PIECE RECOVERED DURING CORRECTIVE WORK MEASURES

SPECIMEN TESTED FOR COMPRESSIVE STRENGTH

STRENGTH = 99 psi

APPENDIX J

PETROGRAPHIC SPECIMENS

(Magnification both photographs x 1.0)

SOUND CONCRETE

CONCRETE WITH DEFICIENT MORTAR

(note the considerably less cement paste and the presence of cracking distress)

APPENDIX K

145

October 18, 1979

PIN 1700.18.325; D96103
GREEN ISLAND BRIDGE, EAST PIER
RESULTS OF BOREHOLE T.V. SURVEY

L. H. Moore, Soil Mechanics Bureau, Rm. 102, Bldg. 7
By: B. E. Butler
E. V. Hourigan, Struct. Des. & Constr. Subdiv., 6th Flr., Bldg. 5

ORIGINAL SIGNED BY
BERNARD E. BUTLER

(1) JJM
(2) WJB
( )
( ) RHF
(3) FSS
( ) TEW
( ) GDT
(4) DGC
( ) DTB
( ) WJM
(5) GGA
( ) GEM

cc C. E. Carlson, Regional Director, Region 1
J. Murphy, Materials Bureau, Rm. 210, Bldg. 7A
J. Sternbach, Constr. Subdiv., Rm. 424, Bldg. 5

Attached is correspondence from Mr. F. R. Irving, Associate Engineering Geologist of this Bureau. This correspondence contains a pair of photographs with overlays which illustrate the results of our borehole television survey. This inspection reinforces our opinion that large voids do not exist in the tremie seal.

Please contact us if you have any questions.

FAW:MVM
Attachment

October 12, 1979

GREEN ISLAND BRIDGE, EAST PIER
BORE HOLE T.V. SURVEY
PIN 1700.18.325

F. R. Irving, Associate Engineering Geologist

B. L. Butler, Associate Soils Engineer

Drill holes DHE and DHF on the subject project were inspected with the Bureau's Borehole T.V. camera. The purpose of the T.V. inspection was to determine the reason for the core loss in the Tremie concrete. The inspection did not reveal any large voids but did show broken up sections containing small voids.

Hole DHF penetrated 7.0 feet of concrete: 0.5 feet of concrete with some contorted seams of cement paste; 3.8 feet of cement paste; and 0.9 feet (0.3 recovered in core) of broken pieces of cement paste over shale bedrock. The top 0.2 feet of the shale was badly broken. Hole DHF was washed out with a hose in an attempt to improve T.V. picture quality. When the camera was reinserted in the hole it could not be lowered beyond the point near the top of rock where chunks of cement paste were noted on the initial survey of the hole. The flowing water from the hose had either eroded out enough of the soft material to fill the drill hole to that point, or had displaced some pieces and blocked the hole.

Hole DHE penetrated 6.3 feet of concrete: 1.4 feet of cement paste containing fine aggregate with a few pieces of coarse aggregate near the bottom, the whole showing contorted bedding; 3.5 feet of cement paste with relatively horizontal bedding and 1.3 feet of broken pieces of cement paste (Fig. 1 and 2).

An attempt was made to flush out Hole DHA-1, however the hose could not be pushed past an obstruction at elevation minus 18+. No attempts were made to survey other holes because of many difficulties, including the interference with the ongoing drilling operations, the problem of cleaning the holes without collapsing the sidewalls and the likelihood of the camera being trapped in the hole by pieces of uncemented coarse aggregate.

FRI:sd
Attachment

Figure 1, Hole [illegible]. Elevation -22+. (magnification approx. x 1.5) Pieces of cement paste (1) and Voids (2). Lighting from above and below picture.

Figure 2, Hole [illegible], Elevation -22.1+. Pieces of cement paste (1) and Voids (2) immediately below Figure 1, near top of rock.

APPENDIX L

CORE TEST RESULTS

COMPRESSIVE STRENGTH

TEST REFERENCES: 79 SD 448-449, 9/20/79
79 SD 480-487, 10/17/79
89 SD 144-156, 3/10/80

DATE(AGE)	CORE	DESCRIPTION	COMPRESSIVE STRENGTH (PSI)
9/20(23 days)	TCE-4	Sound Concrete	5,280
	TCE-6	Sound Concrete	5,220
	TCE-3	Fine Cementitious Material	99
10/17(50 days)	TCE-3	Fine Cementitious Material	800
	TCE-4	Fine Cementitious Material	610
	TCE-5	Sound Concrete	7,390
	TCE-7	Sound Concrete	5,270
	TCE-8	Sound Concrete	6,180
	TCE-9	Sound Concrete	7,390
	TCE-11	Sound Concrete	5,700
3/10(6 1/2 months)	DH-A1	Sound Concrete	4,950
	DH-A1	Sound Concrete	4,100
	DH-C	Sound Concrete	4,610
	DH-L1	Sound Concrete	5,290
	DH-P	Sound Concrete	4,710
	DH-F	Concrete With Deficient Mortar	1,980
	DH-L	Concrete With Deficient Mortar	1,160
	DH-P	Concrete With Deficient Mortar	1,060
	DH-B	Fine Cementitious Material	570
	DH-E	Fine Cementitious Material	860
	DH-E	Fine Cementitious Material	300

AVERAGE COMPRESSIVE STRENGTHS:

Sound Concrete = 5508 psi
Concrete with Deficient Mortar = 1400 psi
Fine Cementitious Material = 292 psi

NOTE: Due to time limitations at the time of testing, the standard 40 hour presoak was omitted for all specimens tested on 9/20/79 and 10/17/79.

APPENDIX M

CORE TEST RESULTS

UNIT WEIGHT

TEST REFERENCES: 79 SD 480-487, 10/17/79
80 SD 144-156, 2/15/80

DATE	CORE	DESCRIPTION	UNIT WEIGHT (lbs/cu.ft.)
10/17/79	TCE-2	Fine Cementitious Material	70.11
	TCE-4	Fine Cementitious Material	69.57
	TCE-5	Sound Concrete	145.60
	TCE-7	Sound Concrete	139.89
	TCE-8	Sound Concrete	145.05
	TCE-9	Sound Concrete	144.12
	TCE-10	Sound Concrete	142.01
	TCE-11	Sound Concrete	142.55
	TCE-3	Fine Cementitious Material	74.93
2/15/80	DH-A1	Sound Concrete	141.88
	DH-A1	Sound Concrete	139.40
	DH-C	Sound Concrete	138.70
	DH-L1	Sound Concrete	140.52
	DH-P	Sound Concrete	143.27
	DH-F	Concrete With Deficient Mortar	113.61
	DH-L	Concrete With Deficient Mortar	139.31
	DH-P	Concrete With Deficient Mortar	137.37
	DH-B	Fine Cementitious Material	53.48
	DH-B	Fine Cementitious Material	49.13
	DH-C	Fine Cementitious Material	65.49
	DH-E	Fine Cementitious Material	72.55
	DH-E	Fine Cementitious Material	50.43

AVERAGE UNIT WEIGHTS:

Sound Concrete = 142.09 pcf
Concrete with Deficient Mortar= 130.10 pcf
Fine Cementitious Material = 63.21 pcf

APPENDIX N
CORE TEST RESULTS
AIR CONTENT

TEST REFERENCE: 80 SPC 80-86, 3/10/80

METHOD: HIGH PRESSURE AIR METER

CORE	DESCRIPTION	AIR CONTENT(%)
DH-C	SOUND CONCRETE	3.1
DH-L1	" "	3.7
DH-P	" "	4.1
DH-L	CONCRETE WITH DEFICIENT MORTAR	2.6
DH-M	" " " "	2.5
DH-B	FINE CEMENTITIOUS MATERIAL	62.5
DH-C	" " "	61.2

NOTE: The high pressure air meter measures the total air content, which is the sum of entrained and entrapped air. Typically, the entrained air content of concrete can be expected to be from 1 to 2% less than the total air content.

METHOD: MODIFIED GRID-COUNT METHOD

CORE	DESCRIPTION	AIR CONTENT(%)
DH-C	SOUND CONCRETE	2
DH-M	CONCRETE WITH DEFICIENT MORTAR	1

NOTE: The modified grid count method is a visual estimate of the entrained air content of concrete, expressed to the nearest 1%.

APPENDIX O
CORE TEST RESULTS
GRAIN SIZE ANALYSIS

TEST REFERENCE: 79 AU 160, 9/20/79

A sample of fine, cementitious material from core TCE-3 was hand pulverized and run through a nest of fine sieves. The resulting gradation is:

SIEVE SIZE	% PASSING
#200	43.6
#230	43.1
#270	42.6
#325	42.1
#400	42.1

The material retained on the #200 sieve was examined. This material is primarily composed of smaller particles cemented together.

APPENDIX P
CORE TEST RESULTS
CHEMICAL ANALYSIS OF
FINE, CEMENTITIOUS MATERIAL

TEST REFERENCES: 79 LU2527, 9/28/79
80 LU 367, 2/28/20

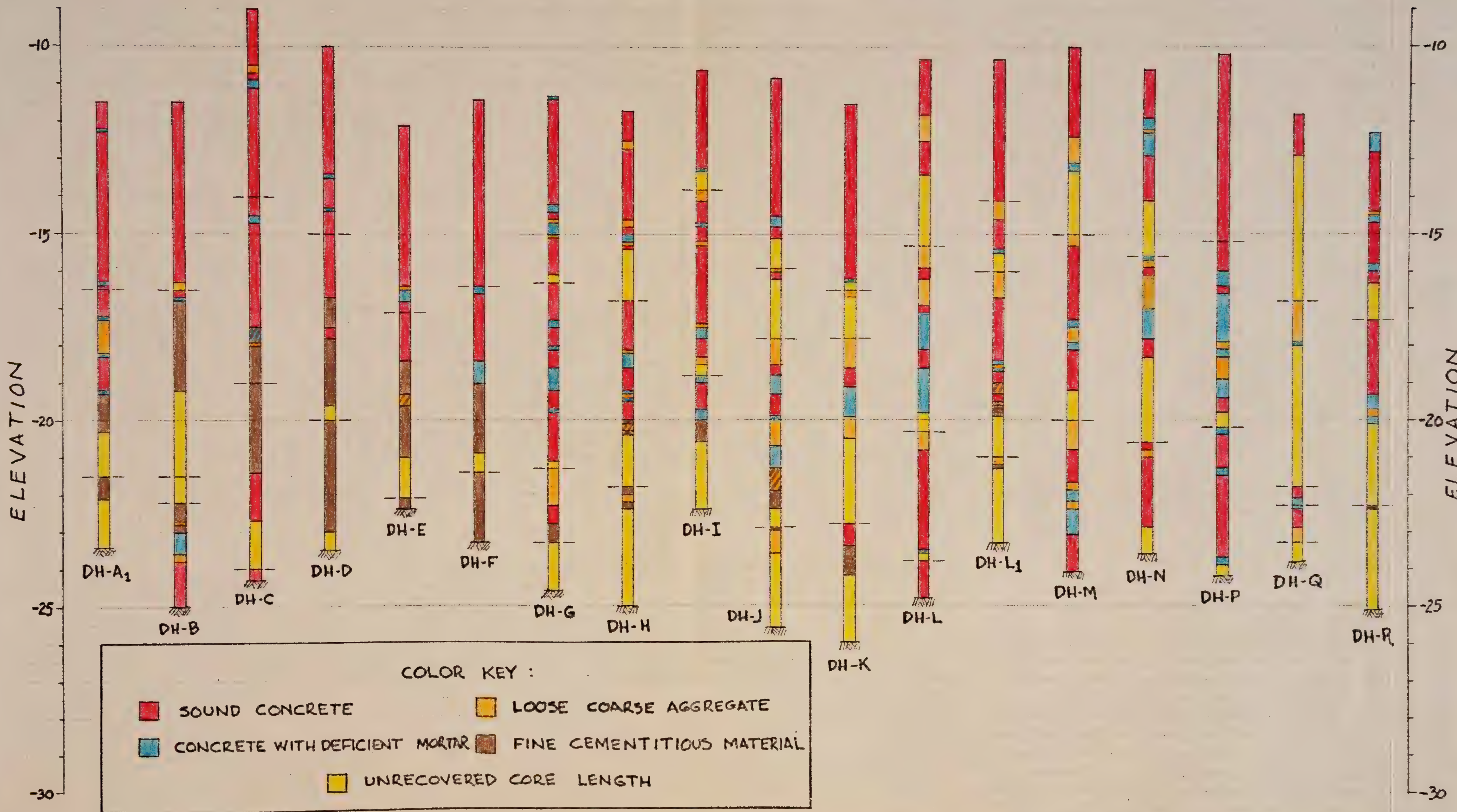
	NYSDOT TYPE II Spec	CORE TCE-3 9/28/79 Sample 1	Sample 2	HOLE C-19 2/28/80 Sample 1	Sample 2
LOSS ON IGNITION(%)	3.0 max.	22.77	22.09	20.59	20.45
SILICA (SiO_2)(%)	21.0 min.	23.78	23.97	23.48	25.61
LIME (CaO)(%)	65.0 max.	44.99	45.74	45.01	44.97
ALUMINA(Al_2O_3)(%)	6.0 max.	3.50	3.60	3.30	2.66
IRON OXIDE(Fe_2O_3)(%)	3.0-5.0	2.80	2.88	2.88	3.35
MAGNESIA(MgO)(%)	5.0 max.	2.45	2.20	2.29	2.18
SULPHUR TRIOXIDE(SO_3)(%)	3.0 max.	0.95	0.93	0.84	0.82
INSOLUBLE RESIDUE(%)	0.50 max.	6.93	6.91	7.99	6.12

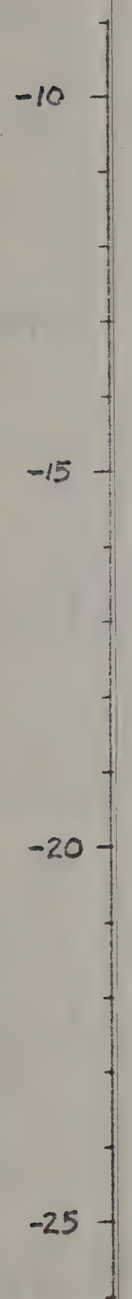

-10
-15
-20
-25

APPENDIX F

TROY - GREEN ISLAND BRIDGE — EAST PIER TREMIE CONCRETE — CORES DH-A1 THRU DH-R

CORES DRILLED BY NYSDOT SOILS PERSONNEL

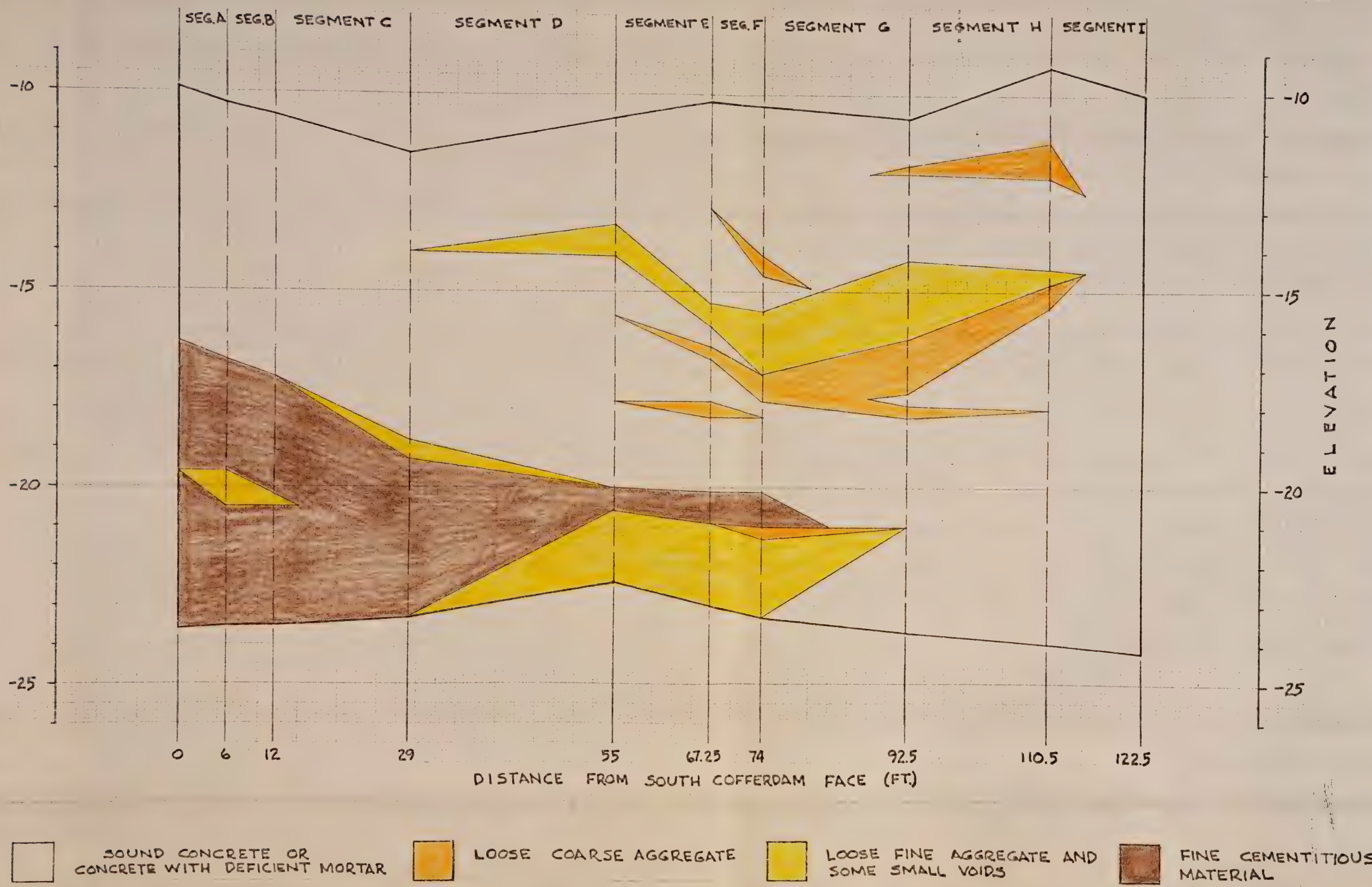



-10
-15
-20
-25

APPENDIX Q

TROY - GREEN ISLAND BRIDGE — MODEL OF EAST PIER TREMIE

LONGITUDINAL SECTION 6' FROM EAST FACE OF PIER

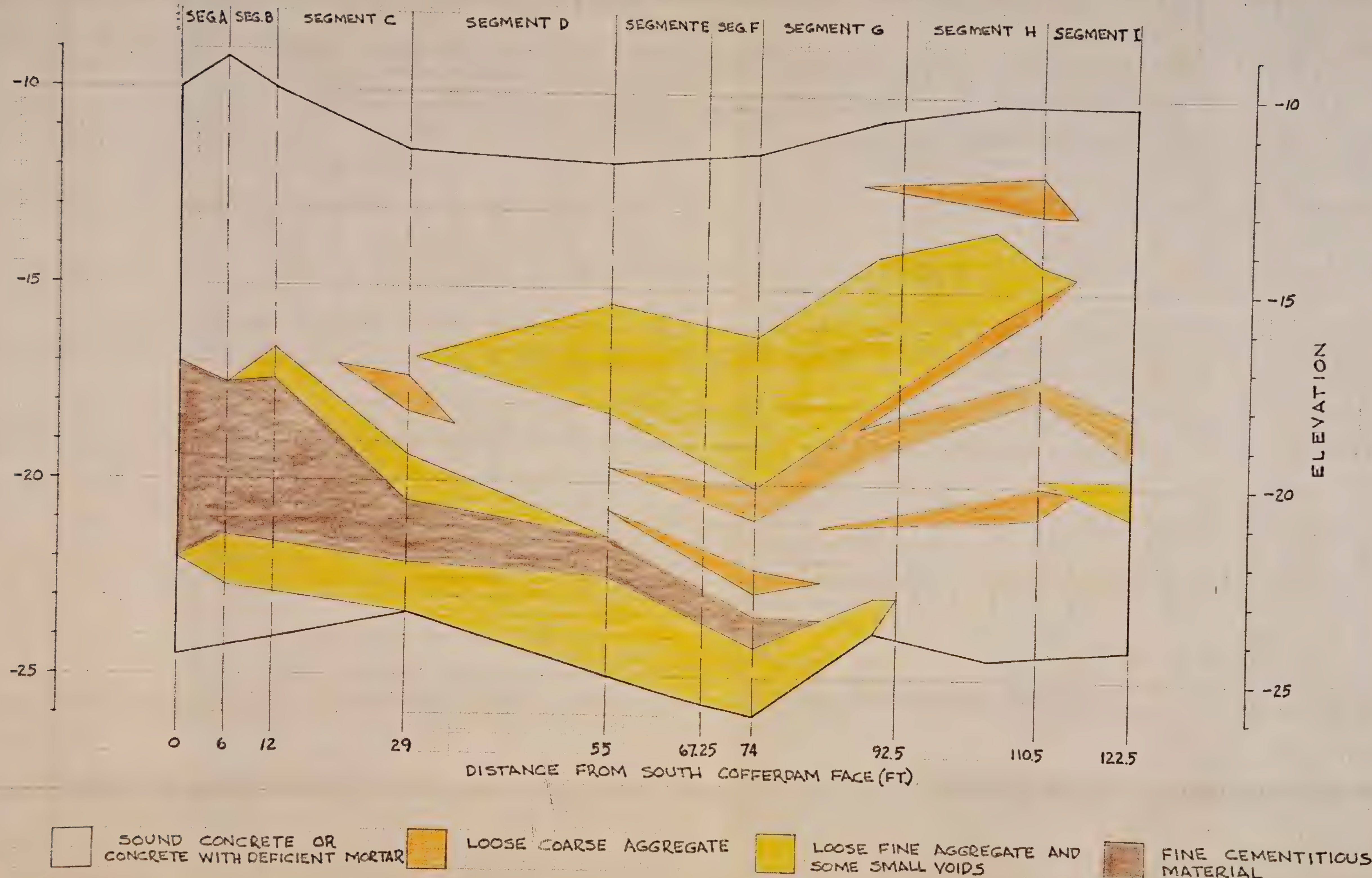


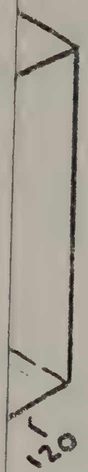
-10
-15
-20
-25

APPENDIX Q

TROY - GREEN ISLAND BRIDGE — MODEL OF EAST PIER TREMIE

LONGITUDINAL SECTION THROUGH PIER CENTERLINE

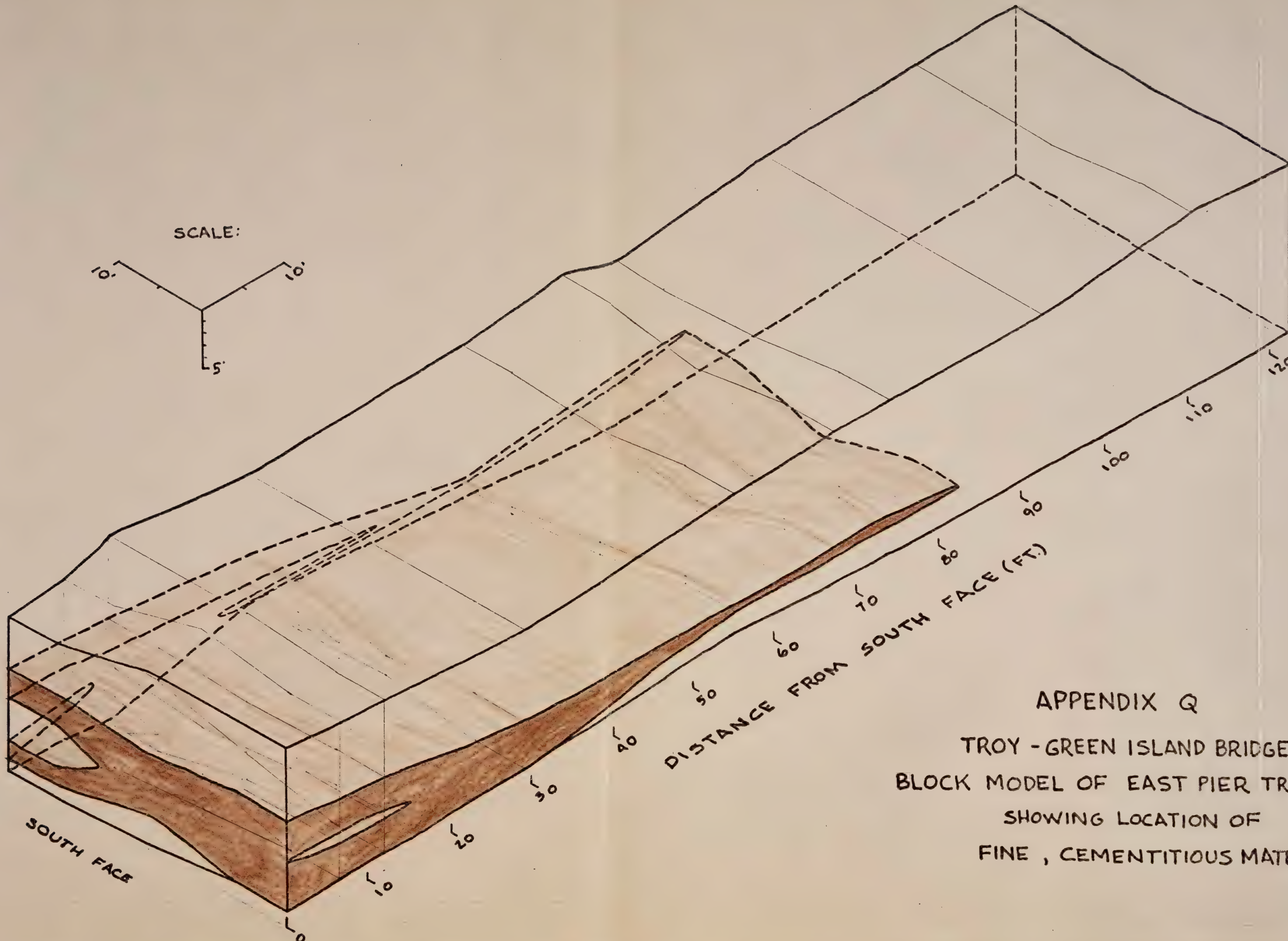




GE

TREMIE

ATERIAL



APPENDIX Q

TROY - GREEN ISLAND BRIDGE
BLOCK MODEL OF EAST PIER TREMIE
SHOWING LOCATION OF
FINE , CEMENTITIOUS MATERIAL

APPENDIX R

VOLUME COMPUTATIONS SUMMARY SHEET

N.Y.S. DEPARTMENT OF TRANSPORTATION

Sheet 1 of ____ Prep. by RWC Date 12/24/79

Checked by JJC Date 5/22/80 Design Ident. SH No. ____

Job Title ____

CONSTRUCTION JOB STAMP

SEGMENT	LENGTH (ft)	Total Volume (c.y.)	R	Y	O	B
A	6	102.35	55.75	8.20	—	33.90
B	6	104.77	62.99	5.37	—	33.42
C	17	270.62	169.47	22.43	1.61	77.10
D	26	390.07	257.22	69.31	3.19	60.35
E	12.25	202.82	123.69	53.39	14.12	11.61
F	6.75	117.35	60.46	36.26	13.20	7.45
G	18.5	318.67	195.07	86.77	31.36	4.93
H	18	313.9	235.97	35.16	39.73	—
I	12	212.21	193.39	4.53	9.28	—
		2033.27	1359.01	327.40	113.04	233.81
		% of total volume →	66.8	16.1	5.6	11.5

Code:

R = Sound concrete & concrete with deficient mortar

Y = Loose fine aggregate, voids & other unrecovered materials

O = Loose coarse aggregate

B = Fine cementitious material

N.Y.S. DEPARTMENT OF TRANSPORTATION

Volume Computations

Sheet 2 of ___ Prep. by RWC Date 12/24/79

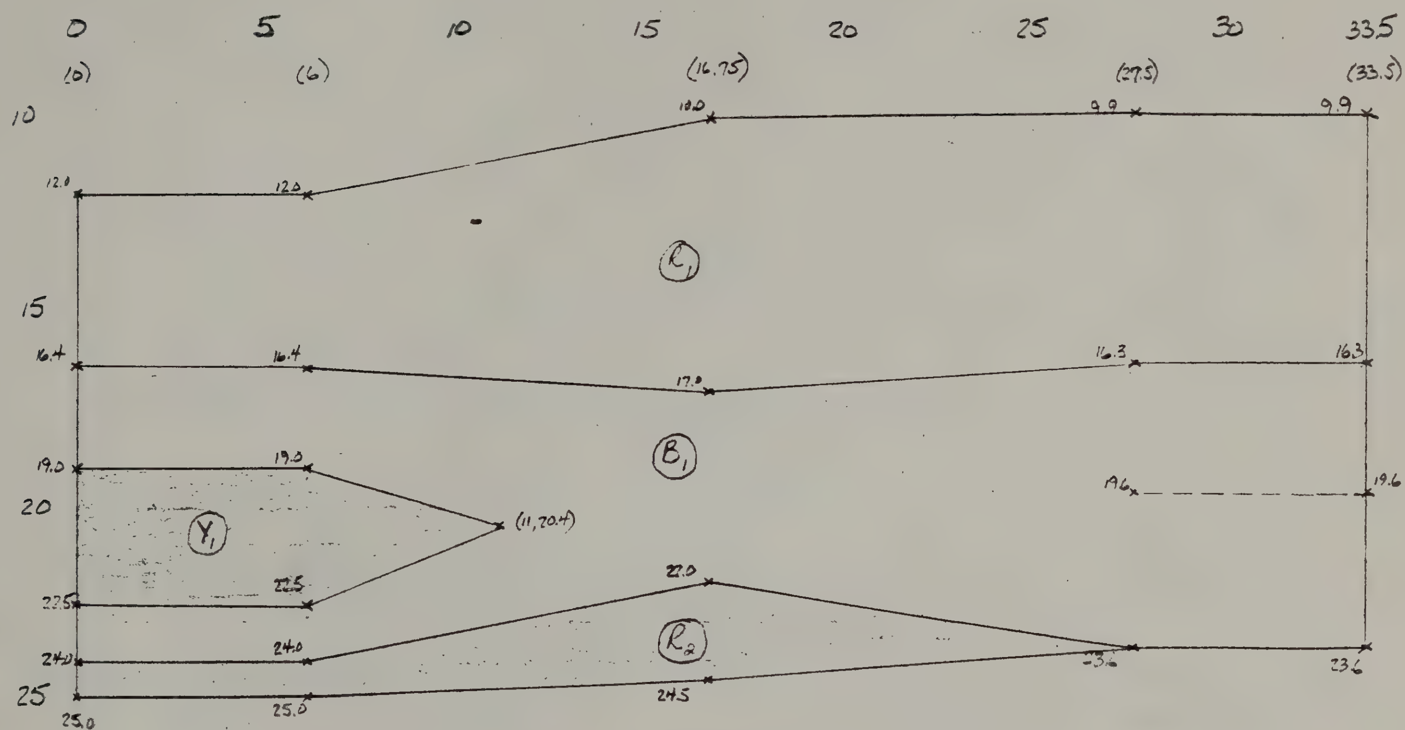
Checked by LJC Date 1/22/80 Design Ident.: SH.No ___

Section at South Face of Syrian

County ___

CONSTRUCTION JOB STAMP

Job Title ___

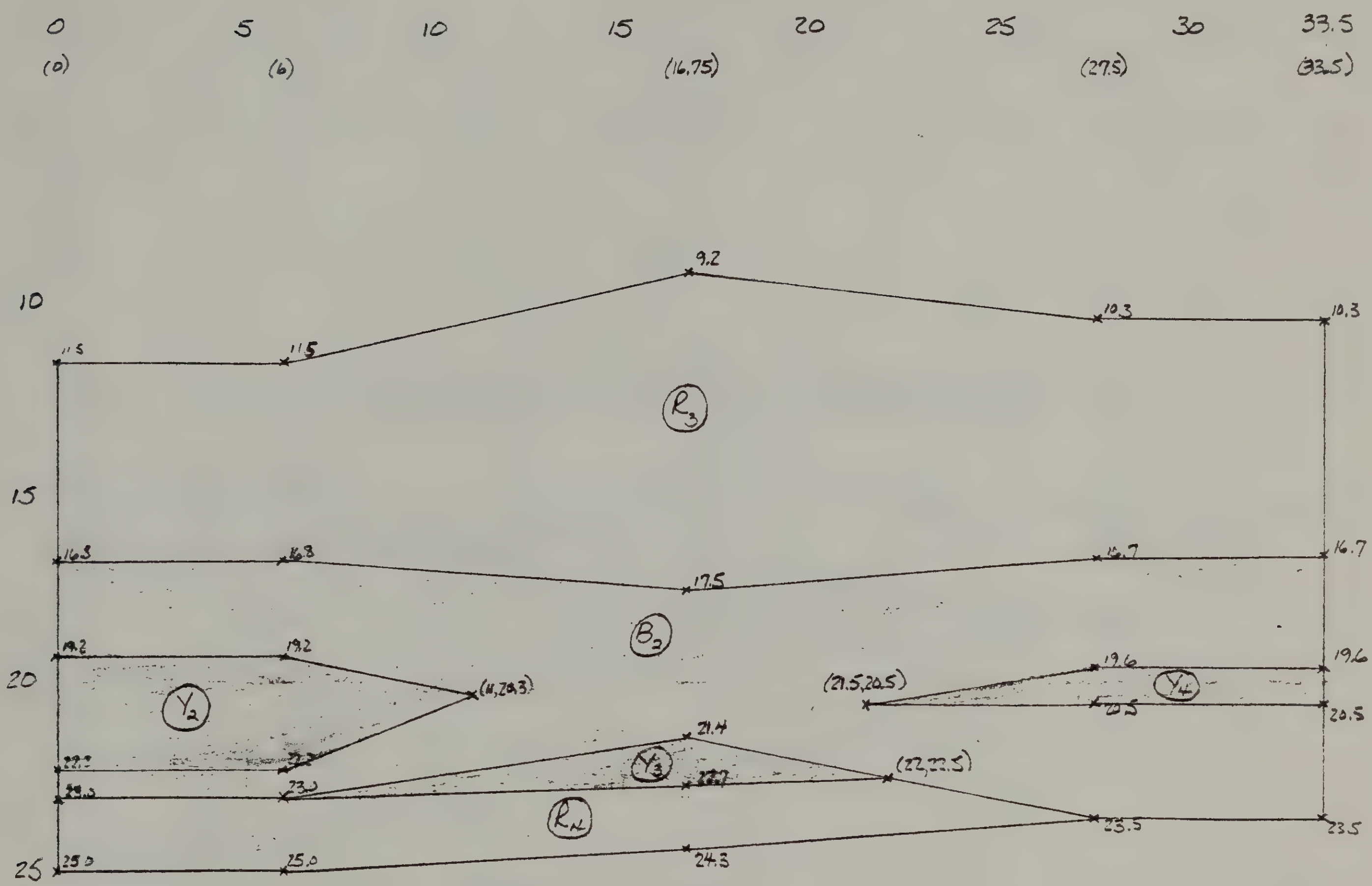


AREAS (ft²):

Total	R	Y	O	B
A = 459.59	R_1 = 198.10	Y_1 = 29.75		B_1 = 193.49
	R_2 = 38.25			

Volume Computations
Section 6' from South Face of Cofferdam to DD

CONSTRUCTION JOB STAMP



Areas (ft^2):

Total	R	Y	O	B
A = 466.04	R_3 = 222.31	Y_2 = 25.50		B_2 = 156.60
	R_4 = 43.13	Y_3 = 10.40		
		Y_4 = 8.10		

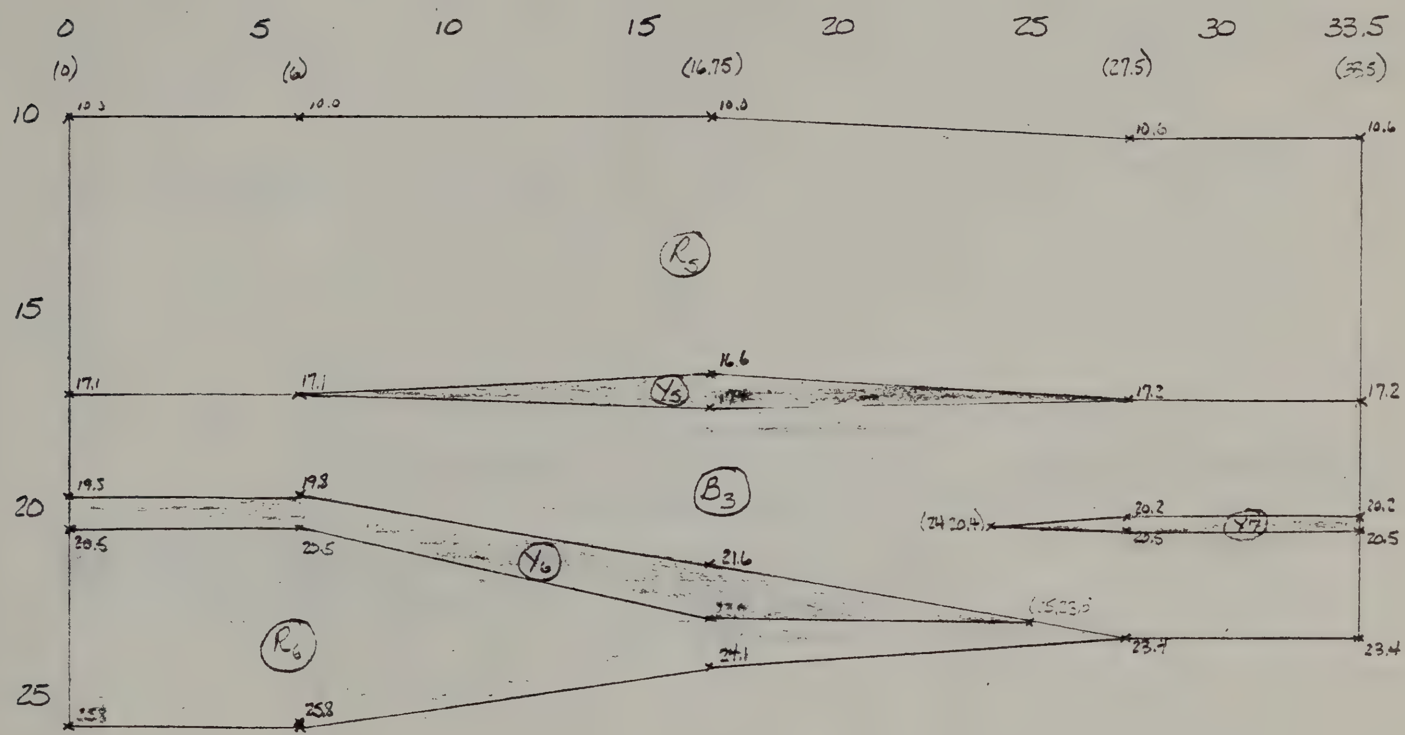
Volume Computations
Section 12' from south face of cofferdam

N.Y.S. DEPARTMENT OF TRANSPORTATION

Sheet 4 of ____ Prep. by RWC Date 12/24/79

Checked by AK Date 5/24/80

CONSTRUCTION JOB STAMP



Areas (ft^2) :

Total	R	Y	O	E
A = 476.90	R_5 = 226.79	Y_5 = 8.60		B_3 = 144.16
	R_6 = 74.71	Y_6 = 20.31		
		Y_7 = 2.33		

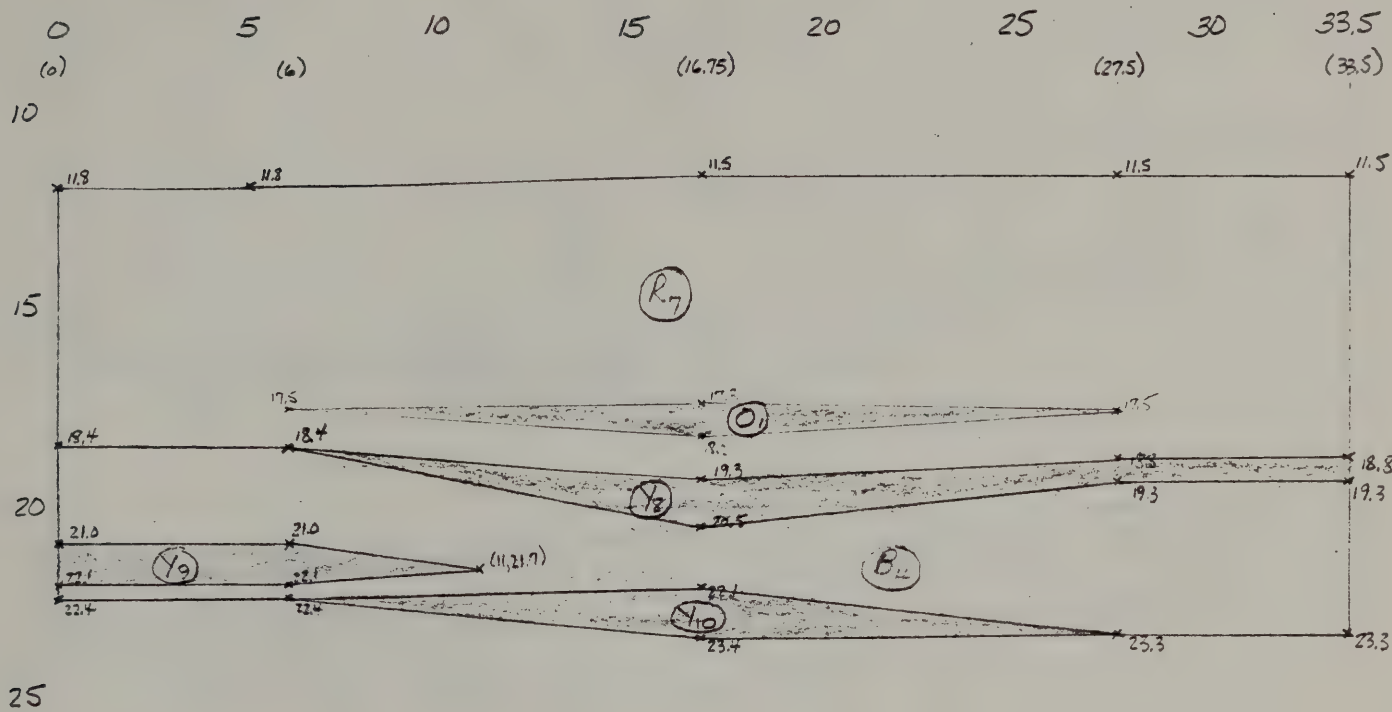
Volume Computations
Section 29' from South Face of Cofferdam

N.Y.S. DEPARTMENT OF TRANSPORTATION

Sheet 5 of ____ Prep. by RWC Date 12/24/79

Checked by ____ Date 5/23/80 Design Ident. SH.No. ____

CONSTRUCTION JOB STAMP



Areas (ft^2):

Total	R	Y	O	B
A = 332.73	R_7 = 232.23	Y_8 = 18.59	O_1 = 9.68	B_4 = 98.35
		Y_9 = 9.35		
		Y_{10} = 13.98		

Volume Computations
Section 55' from South End of Cofferdam

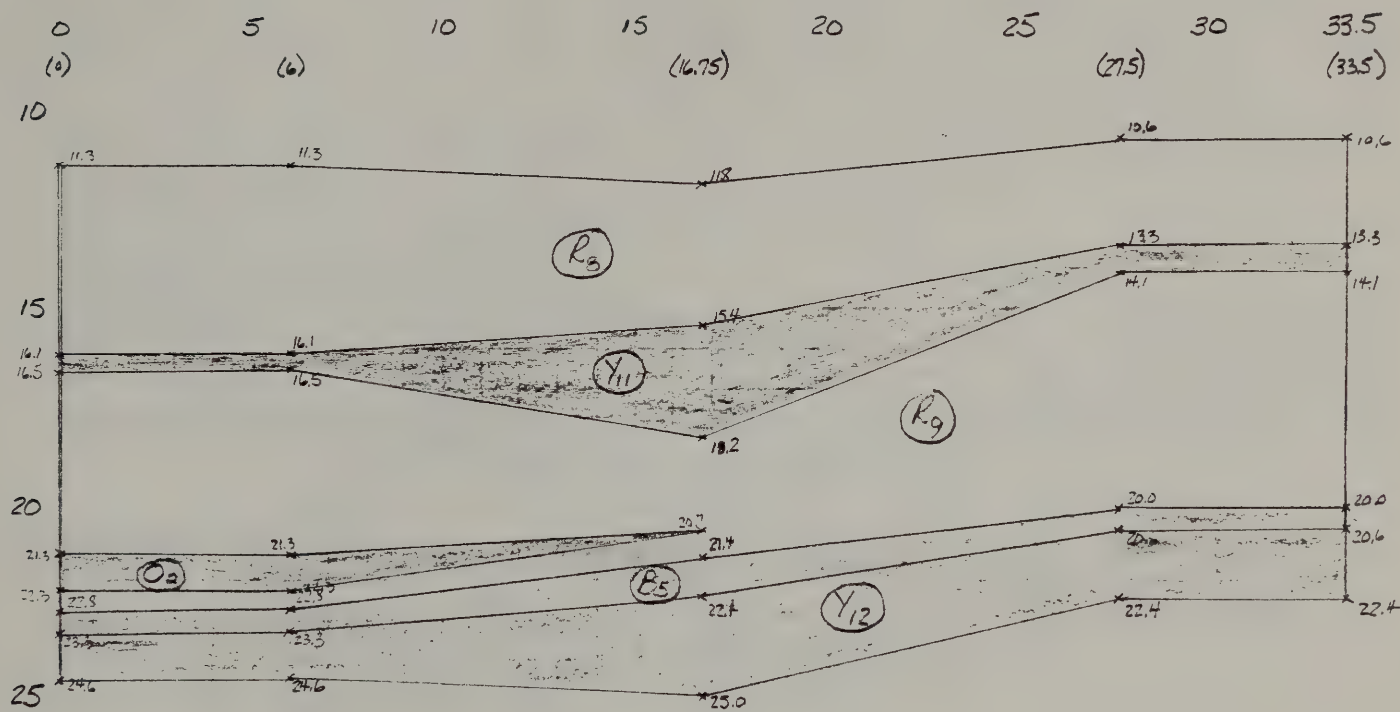
N.Y.S. DEPARTMENT OF TRANSPORTATION

Sheet 6 of ____ Prep by RJC Date 12/27/79
Checked by AJC Date 5/23/80

County ____

CONSTRUCTION JOB STAMP

Job Title ____



Areas (ft²):

Total	R	Y	O	B
A = 427.41	R_8 = 124.01	Y_{11} = 43.75	O_2 = 11.33	B_5 = 23.26
	R_9 = 161.80	Y_{12} = 63.21		

Volume Computations

Section 67.25' from South End of Cofferdam

N.Y.S. DEPARTMENT OF TRANSPORTATION

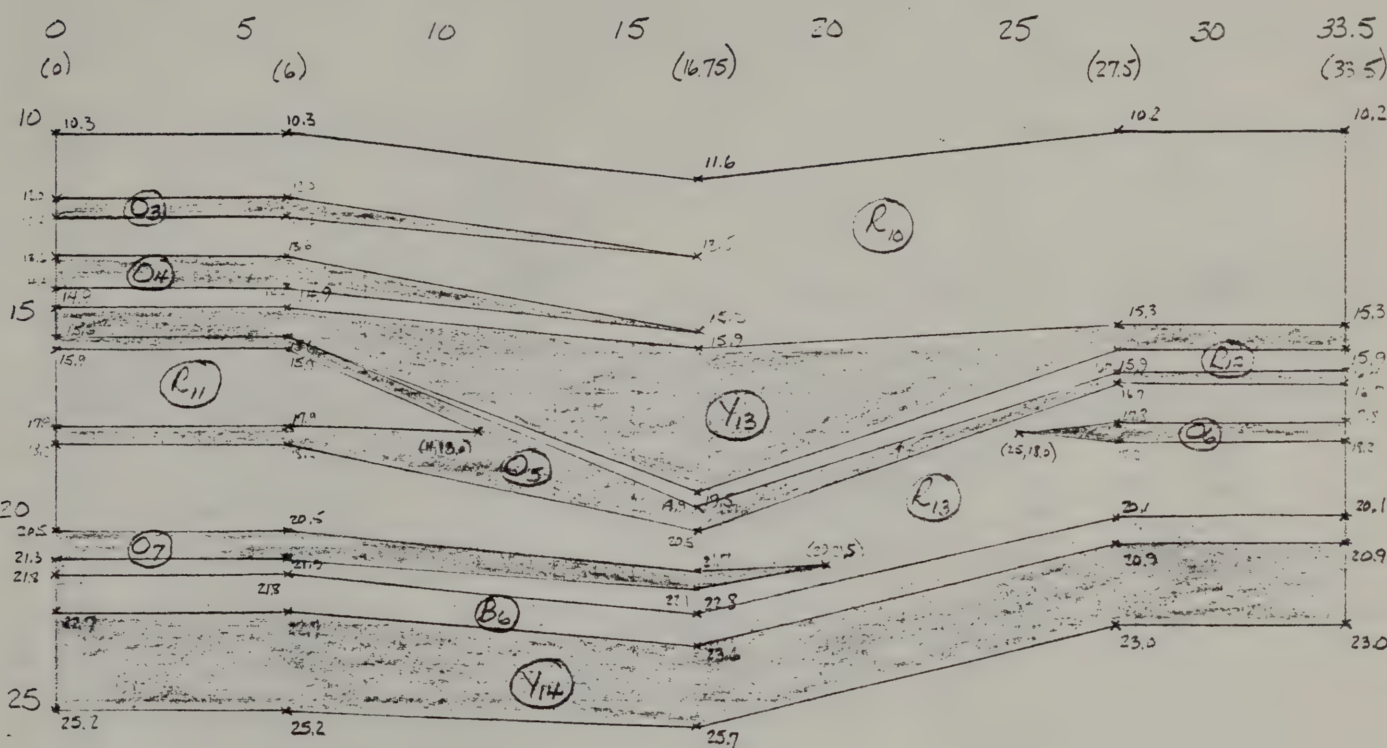
Sheet 7 of ____ Prep. by RWC Date 12/24/79

Checked by JJC Date 5/23/80

County ____

CONSTRUCTION JOB STAMP

Job Title ____



Areas (ft^2):

Total	R	Y	O	B
A = 466.66	R_{10} = 142.91	Y_{13} = 53.49	O_3 = 4.55	B_6 = 27.94
	R_{11} = 17.00	Y_{14} = 74.90	O_4 = 9.10	
	R_{12} = 9.99		O_5 = 22.44	
	R_{13} = 39.55		O_6 = 2.90	
			O_7 = 11.90	

Volume Computations
Section 74' from South End of Cofferdam

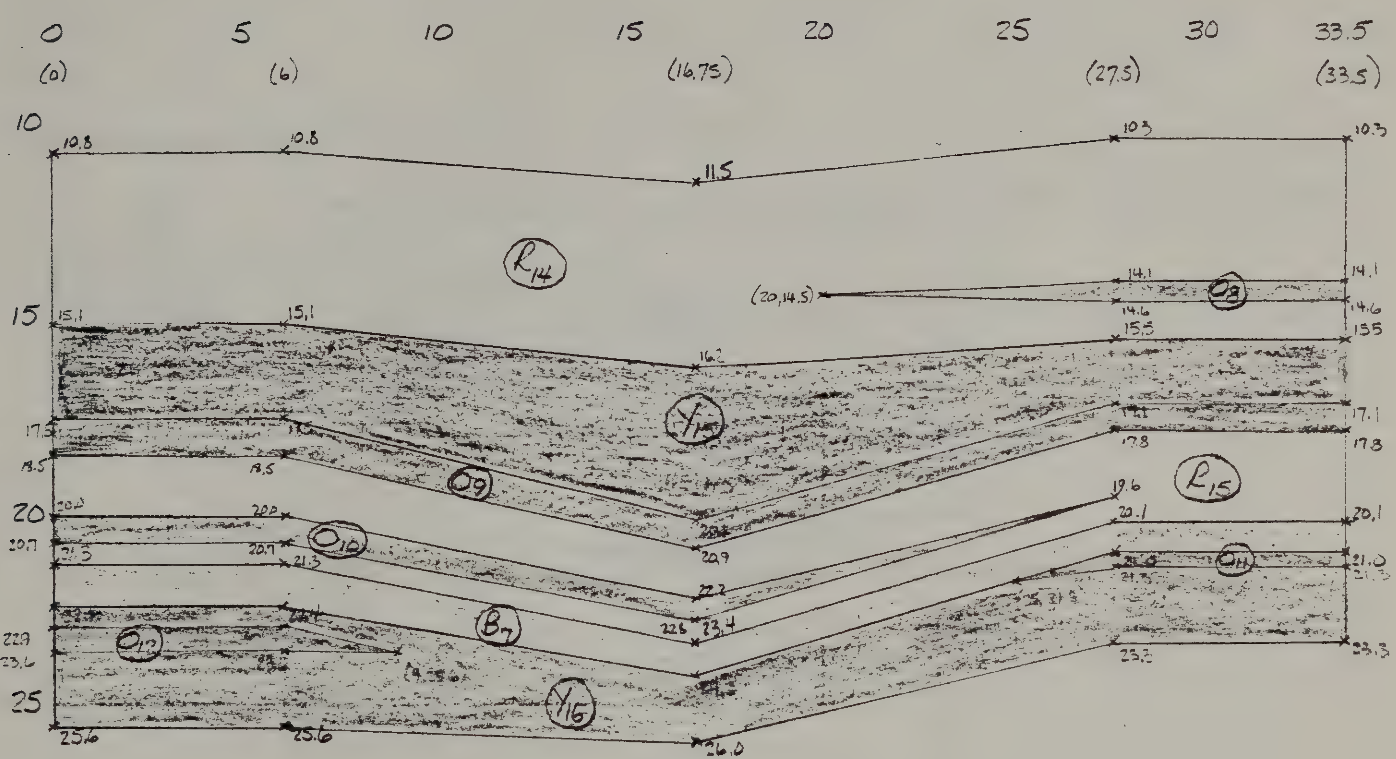
N.Y.S. DEPARTMENT OF TRANSPORTATION

Sheet 8 of ____ Prep. by RJC Date 12/24/79

Checked by JPL Date 5/23/80

CONSTRUCTION JOB STAMP

Job Title ________



Areas (ft^2):

Total	R	Y	O	B
A = 472.10	R_{14} = 153.71	Y_{15} = 37.43	O_8 = 4.33	B_7 = 31.65
	R_{15} = 70.43	Y_{16} = 74.19	O_9 = 27.94	
			O_{10} = 14.41	
			O_{11} = 2.13	
			O_{12} = 5.25	

Volume Computations
Section 92.5 from South Face of Cofferdam

N.Y.S. DEPARTMENT OF TRANSPORTATION

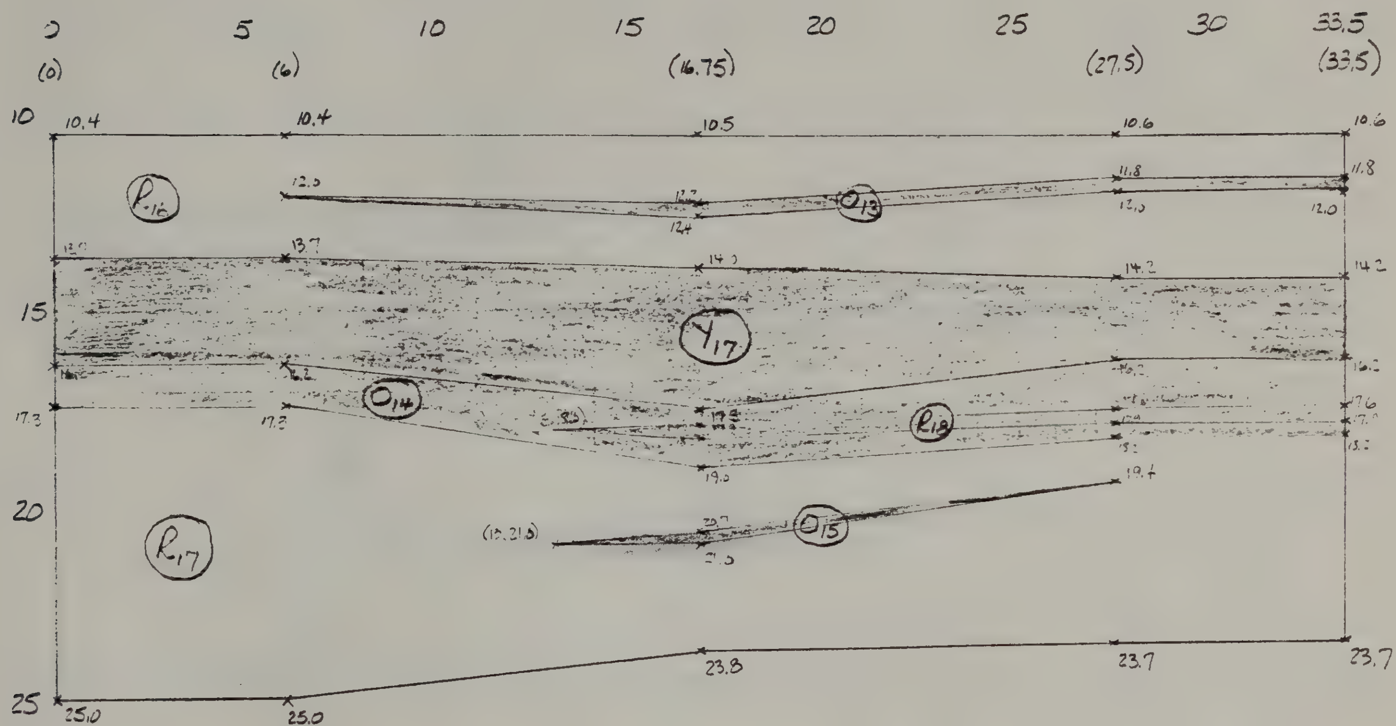
Sheet 9 of ____ Prep. by RWC Date 12/24/79

Checked by [illegible] Date 5/23/80 Design Ident.: SH No. ____

County ____ P.I.N. ____

CONSTRUCTION JOB STAMP

Job Title ____



Areas (ft^2):

Total	R	Y	O	B
A = 458.06	R_{16} = 111.69	Y_{17} = 88.81	O_{13} = 4.43	
	R_{17} = 199.57		O_{14} = 45.30	
	R_{18} = 5.59		O_{15} = 2.13	

Volume Computations
Section 110.5' from South Face of Cofferdam

N.Y.S. DEPARTMENT OF TRANSPORTATION

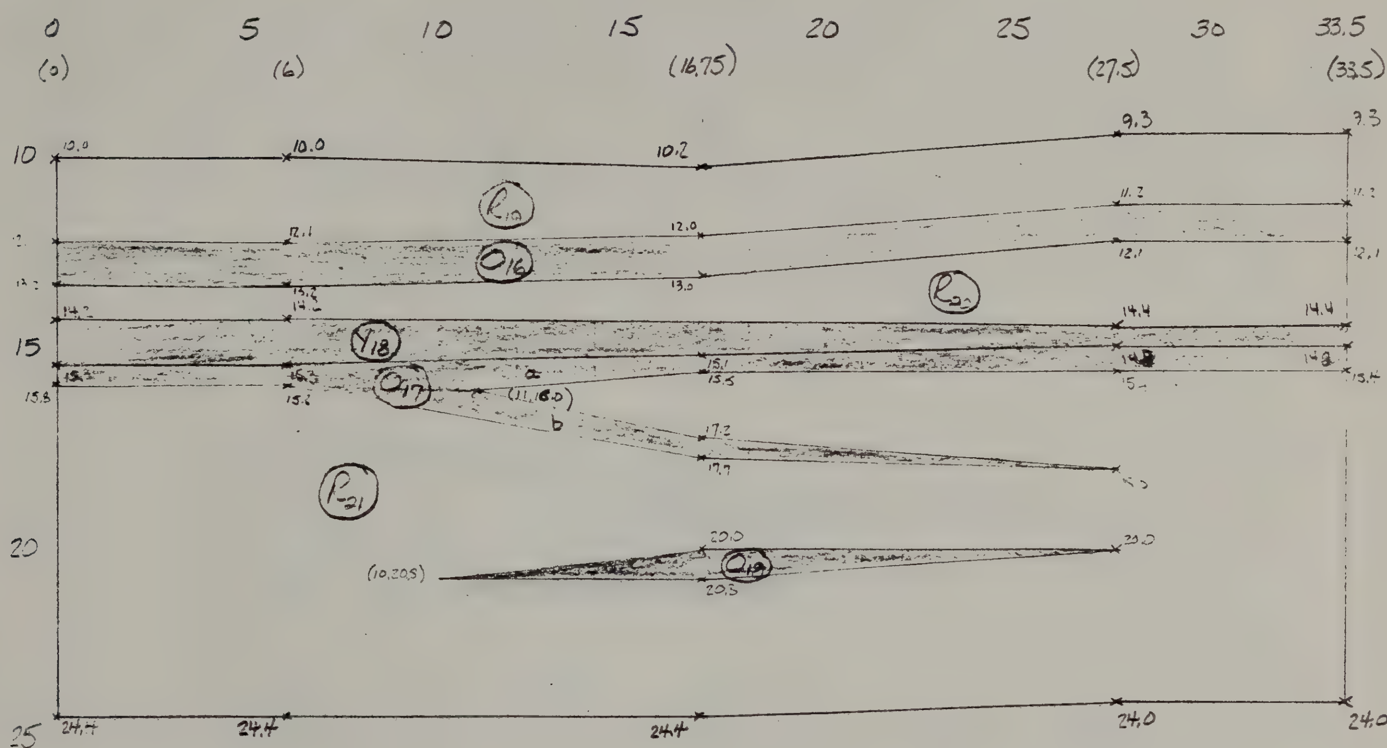
Sheet 10 of ____ Prep. by RWC Date 12/24/79

Checked by JPC Date 5/23/80

County ________

CONSTRUCTION JOB STAMP

Job Title ________



Areas (ft^2):

Total	R	Y	O	B
A = 483.66	R_{19} = 64.85	Y_{18} = 25.66	O_{16} = 33.50	
	R_{20} = 51.51		O_{17} = 26.44	
	R_{21} = 274.70		O_{18} = 7.00	
			O_{17a} = 18.64	
			O_{17b} = 7.80	

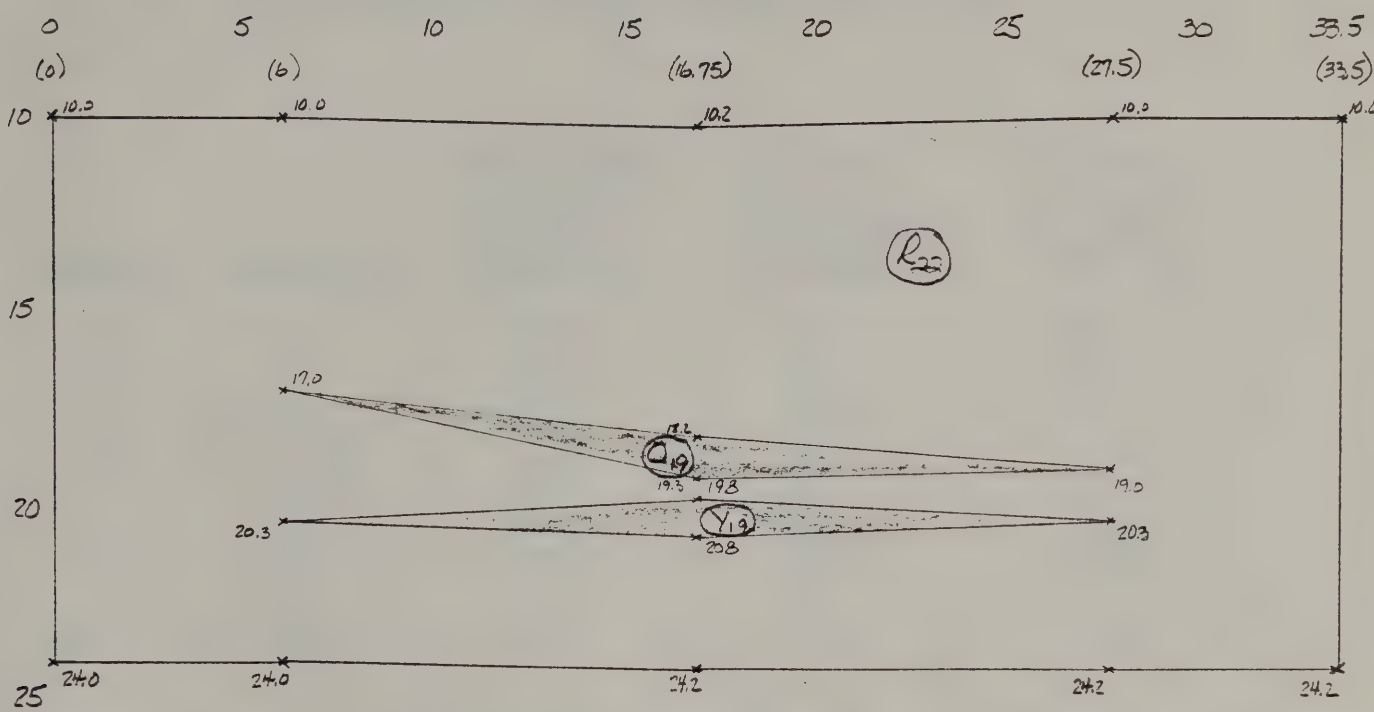
Volume Computations
Section at North Face of Cofferdam

N.Y.S. DEPARTMENT OF TRANSPORTATION

Sheet 11 of ____ Prep. by RWC Date 12/24/79

Checked by JPC Date 5/23/80

CONSTRUCTION JOB STAMP



Areas (ft²):

Total	R	Y	O	B
A = 471.28	R_{22} = 448.70	Y_{19} = 10.75	O_{19} = 11.83	

APPENDIX S
EAST PIER TREMIE MODEL
AVERAGE UNIT WEIGHT OF TREMIE SECTIONS
EQUIVALENT HEIGHT OF SOUND CONCRETE FOR SECTIONS

SEGMENT	LENGTH(FT)	AVG. HEIGHT OF MATERIAL IN MODEL SEGMENT(ft)	EQUIVALENT HEIGHT OF SOUND CONCRETE IN SEGMENT(ft)	AVERAGE UNIT WEIGHT OF MODEL SEGMENT(pcf)
A	6	13.8	10.5	108.3
B	6	14.1	11.2	112.8
C	17	12.8	10.4	115.1
D	26	12.1	10.2	120.1
E	12.25	13.3	11.4	120.9
F	6.75	14.0	11.5	116.5
G	18.5	13.9	12.0	122.5
H	18	14.1	12.9	130.4
I	12	14.3	13.9	138.6
TOTAL	122.5	13.4	11.5	122.2

NOTES: 1) The estimates of average unit weights are based on the following unit weights for different tremie components:

sound concrete = 142 pcf
concrete with deficient mortar = 137 pcf
loose coarse aggregate = 105 pcf
loose fine aggregate = 90 pcf
fine cementitious material = 65 pcf

2) For volume computations, sound concrete and concrete with deficient mortar are considered together. It is assumed that 85% of this combined volume is sound concrete.

3) Segment A is the segment closest to the south face of the tremie.